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STACKS-S.B.T.



HSL No. 77-11

November 1977

# Highway Safety Literature

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U.S. Department of Transportation National Highway Traffic Safety Administration

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**SAE:** Society of Automotive Engineers, Dept. HSL, 400 Commonwealth Drive, Warrendale, Pa. 15096. Order by title and SAE report number.

**TRB:** Transportation Research Board, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, D.C. 20418.



## **ABSTRACT CITATIONS**

FORMAT OF ENTRIES IN HIGHWAY SAFETY LITERATURE

NHTSA accession number ----- HS-013 124

Title of document ----- **MAXIMUM BRAKE PEDAL FORCES PRODUCED BY MALE AND FEMALE DRIVERS**

Abstract ----- The object of this research was to obtain data concerning the maximum amount of brake pedal force that automobile drivers were able to sustain over a period of ten seconds. Subjects were told to apply the brakes in the test car as they would in a panic stop, and to exert as much force as possible on the pedal over the entire ten second test period. A total of 84 subjects were tested, including 42 males and 42 females. The results indicated that there is a wide distribution of values which characterizes the pedal force that the subjects were able to generate. Male subjects produced generally higher forces than did females. Over half the women tested were unable to exert more than 150 lbs. of force with either foot alone, but when both feet were applied to the pedal, force levels rose significantly.

Personal author(s) ----- by C. R. VonBuseck

Corporate author (or author's affiliation) ----- General Motors Corp.

Publication date; pagination ----- 1973? ; 18p

Supplementary note ----- Excerpts from Maximum Parking Brake Forces Applied by Male and Female Drivers (EM-23) BY R. L. Bierley, 1965, are included.

Availability ----- Availability: Corporate author

NHTSA accession number ----- HS-018 924

Title of document ----- **NATURAL FREQUENCIES OF THE BIAS TIRE**

Abstract ----- The lowest natural frequencies of a bias tire under inflation pressure are deduced by assuming the bias tire as a composite structure of a bias-laminated, toroidal membrane shell and rigorously taking three displacement components into consideration. The point collocation method is used to solve a derived system of differential equations with variable coefficients. It is found that the lowest natural frequencies calculated for two kinds of bias tire agree well with the corresponding experimental results in a wide range of inflation pressures. Results of the approximate analysis show that the influences of the in-plane inertia forces on natural frequency may be considered small, but the influences of in-plane displacements are large, particularly on the natural frequency of the tire under low inflation pressure.

Personal author(s) ----- by Masami Hirano; Takashi Akasaka

Journal citation ----- Publ: Tire Science and Technology v4 n2 p86-114 (May 1976)

Publication date ----- 1976; 6refs

Availability ----- Availability: See publication

HS-020 983

## **TRAFFIC ACCIDENT FACTS 1976. AN ILLUSTRATED ANALYSIS OF ACCIDENT RECORDS**

Statistical data from the Florida Highway Patrol on accidents in the state during 1976 are presented in tabular and graphical form. Information from traffic accident records is broken down into the following categories: feature facts (outline of statistics for number of accidents, persons killed and injured, pedestrians involved in accidents, mileage death rates, sex of drivers involved in accidents, comparison with 1975 data, ratio of injured to killed, use of seat belts); time lines (outline of daily traffic accident toll, day of week and time of day for accidents); contributing causes of accidents; accidents and fatalities by month; accidents by time of day and day of week; fatal accidents by time of day and day of week; holiday traffic accidents; traffic deaths by county (1972-1976); traffic fatality map; state, county, and city maintained roads (number of miles of paved and unpaved roads 1967-1976); traffic statistics (1957-1976, licensed drivers, registered vehicles, mileage, accidents, nonfatal injuries, deaths, mileage death rates); traffic trends (1956-1976, deaths, vehicle miles, mileage death rates); estimated property damage (1967-1976); estimated economic loss (1967-1976); total traffic deaths; statewide conditions of drivers and pedestrians (drinking, no-drinking, and not stated); age distribution of drivers; sex and residence of drivers; pedestrian deaths and injuries by age; pedestrian fatalities--male and female by age; pedestrian actions (e.g. crossing at intersection or in crosswalk); pedestrian and pedalcyclist fatalities (1967-1976); and annual standard summary.

Florida Dept. of Hwy. Safety and Motor Vehicles, Accident Records Section  
1977, 33p  
Availability: Corporate author

HS-020 984

## **ENERGY STATISTICS. A SUPPLEMENT TO THE SUMMARY OF NATIONAL TRANSPORTATION STATISTICS. ANNUAL REPORT**

A compendium of selected time-series data describing the transportation, production, processing, and consumption of energy is presented in graphical and tabular form. It is essentially an updated version of the 1975 edition, with a few additions, and emphasizes statistics relating to the role of transportation in the energy supply infrastructure, and transportation as a consumer of energy (although additional data relating to energy are included as well). The statistics have been gathered from the Department of Transportation, the Interstate Commerce Commission, the Department of the Interior, the American Petroleum Institute, and other government and private sources. The report is divided into three sections. The first contains such items as the revenues and expenses of oil pipeline companies, number and capacities of U.S. tank ships, and the total crude oil transported in the U.S. by method of transportation. The second deals with the growth over time of the U.S. oil and natural gas reserves, refinery capacity, and yields. The final section provides information on trends in the demand for fuel and power. Included are the gasoline and oil costs of automobiles of different sizes, the consumption of petroleum by type of product, the electrical energy consumed

by the local transit industry, and other important statistics describing the supply and demand for energy.

by William F. Gay  
Department of Transportation, Transportation Systems Center,  
Kendall Square, Cambridge, Mass. 02142  
Rept. No. DOT-TSC-OST-76-30; 1976; 143p 40refs  
Availability: GPO

HS-020 985

## **FUEL ECONOMY OF HEAVY DUTY VEHICLES**

A fuel economy analysis was performed on data from a study of emissions from heavy-duty vehicles. The emission testing involved 30 trucks and included two-axle single unit trucks, three-axle single unit trucks, and tractor-trailer trucks. Eighteen gasoline and twelve diesel-engine-powered trucks constituted the 30 tested. All measurements were taken on a chassis dynamometer. From the emission measurements, fuel consumption was calculated using the carbon balance technique. Although both transient and steady-state data were gathered, only the steady-state fuel consumption was analyzed in this effort. The steady-state testing involved running the trucks at speeds of 5, 10, 15, 20, 30, 40, and 55 mph. Also, three different test weights were used for each truck: empty, half load, and full load. For diesel-powered trucks, peak fuel economy was attained at 30 mph. For gasoline-powered trucks, peak fuel economy occurred at 40 mph for light load test conditions, while for heavier load test conditions peak fuel economy occurred at 30 mph. In general, best fuel economy for heavy-duty trucks occurs between 30 and 40 mph. As speed is increased above 30 to 40 mph, fuel economy decreases.

by Chester J. France  
Environmental Protection Agency, Emission Control  
Technology Div.  
Contract EPA-68-03-2147  
Rept. No. EPA-HDV-76-01; 1976; 29p  
Availability: Corporate author

HS-020 986

## **WHY ARE CHILDREN INJURED IN TRAFFIC? CAN WE PREVENT CHILD ACCIDENTS IN TRAFFIC? THE SKANDIA REPORT 2**

An investigation was made of traffic accidents in Sweden during the years 1968 and 1969 which involved children aged 1-10 years in which the children were active participants in traffic. An analysis was made of 182 complete police investigations including preliminary investigation records. The major proportion of children were pedestrians, a minor part bicyclists; a few others were using winter vehicles, etc. Most of the children were out alone followed in number by children out with friends and finally those in the company of adults. It was found that one-seventh of the children behaved correctly as pedestrians but were injured anyway. One-fifth of the children who were bicyclists were hit by cars in spite of the fact that they behaved correctly. The supervisors (parents, grandparents, personnel at the preschool/schools, etc.) displayed in many cases a lack of knowledge about what can be expected from a child in traffic, so they overestimated the ability of the children. The drivers who had collided with the children were

between the ages of 15-71 years. The drivers were divided into bicycle, moped, motorcycle, and car drivers. They also expected too much from the children. The mistakes they made concerning child pedestrians and bicyclists are analyzed as well as the age of the drivers and the length of time they had held their licenses in relation to their accident behavior. Statements made by children and adults in the preliminary investigation records are discussed and give a picture of their conception of each other as fellow traffic participants. The stationary traffic environment in which the accidents took place (residential areas, preschools/schools, family day homes, playgrounds, streets and roads, pedestrian crossings, parking lots, parking places, news-stands, etc.) is analyzed. The moving traffic environment, especially the large vehicles (trucks with or without trailers, buses, garbage trucks, tractors, etc.) is dealt with separately. Finally, the question whether child accidents in traffic can be prevented is discussed. The traffic dangers for children, mainly children on their way to school, are discussed on the basis of previous chapters and current international literature published after this investigation was made. The supposed responsibility of the children in causing traffic accidents is discussed as well as their traffic ability. It is shown that it is impossible to radically lower the amount of children's accidents by teaching them safety measures, even though this still has to be done as well as possible. Demands will be made that all adult Swedes be informed about children's behavior in normal traffic situations, behavior that is dependent upon their development. Furthermore, there are demands for a substantial expansion of the research concerning children's safety in the traffic environment.

by Stina Sandels  
Skandia Insurance Co. Ltd., S-103 60 Stockholm 3, Sweden  
1974; 89p Brefs  
See also HS-020 987.  
Availability: Corporate author

HS-020 987

## CHILDREN IN TRAFFIC. THE SKANDIA REPORT 1

Statistical data are presented for traffic accidents in Sweden during 1968 and 1969 in which children up to and including the age of ten were actively involved. Source material for this study are forms containing information about the accidents which were submitted to the Swedish Central Bureau of Statistics by the police authorities. These forms include a number of specified data, together with a sketch and a brief account of the course of events. The specified data utilized comprised the ages and sex of the children and the drivers, the injury to the child, the length of time the driver has been in possession of a driving license, the traffic category of the child and the driver, as well as the hour, day of the week, and month when the accident occurred. The remaining information for the description of the accidents, such as the actions of the child, the conditions affecting range of vision and other circumstances at the time of the accident has been obtained from the sketch and the brief written account.

by S. Lindensjö; K. Mattsson; S. Sandels  
Barnpsykiologiska institutet, Stockholm, Sweden; Skandia Insurance Co. Ltd., S-130 60 Stockholm 3, Sweden  
1971; 22p 2refs  
See also HS-020 986.  
Availability: Skandia Insurance Co. Ltd., S-103 60 Stockholm 3, Sweden

HS-020 988

## VIRGINIA'S HIGHWAY SAFETY PROGRAM

Virginia's highway safety public information program is educational and entertaining in nature, using various media outlets and aiming information at groups such as out-of-state travelers, pedestrians, bike riders, and motorcyclists. Travelers are reached by a statewide radio network, broadcast by the Virginia Traveler Information Service, which alerts motorists to hazardous road conditions, road tie-ups, or special events causing congestion. Travel and Information Centers distribute brochures with advice on prime and alternate routes, and highway safety information. Brochures, posters, and "Send Help" litter bags were distributed state-wide in 1976. A publicity campaign for "right turn on red," instituted 1 Jun 1977, used radio, television, and newspaper releases as well as "Five Easy Steps" flyers and bus placards for pedestrians. The "Remember 55" campaign, begun in Oct 1976, used a media star, radio, releases, bumper stickers, and tent cards in restaurants, preceded by a survey of public attitudes toward the speed limit. A holiday radio series focuses on heavy traffic holidays for special broadcasts on highway safety. A 1976 motorcycle safety campaign relied on radio materials and television spots featuring media stars. Brochures containing motorcycle safety quizzes were also used. The Virginia Alcohol Safety Action Program, begun in 1975, initiated to offer education/treatment programs rather than fines and jail sentences, uses entertaining film presentations and brochures distributed around holidays. A pedestrian education program features a puppet show, video tape presentations, and films. Programs begun in 1977 are for safety belts, motorcycles, railroads, drugs, and visually handicapped pedestrians. Films, radio and television public service spots, news releases, and brochures will be used. Research programs are conducted prior to the beginning of all highway safety programs in Virginia, and survey evaluations are conducted after institution of programs.

by John T. Hanna; Debby Mills Harden  
Publ: Transportation Engineering v47 n7 p24-8 (Jul 1977)  
1977  
Availability: See publication

HS-020 989

## RIDING PATTERNS OF THE REGULAR ADULT BICYCLIST

Adult bicyclists who ride regularly (defined as people who ride at least three times a month during months of suitable climatic conditions) have riding patterns which, if known, can be used in traffic planning and accident pattern research. Data for this study of riding patterns are based on 3,270 questionnaire responses from members of the League of American Wheelmen (LAW). Respondents, representing all 50 states, were 88% male, and average age 38. Average travelling distance in one year was 2,300 miles. Recreation/touring trips account for over 50% of total miles, and work or school commute trips account for almost one third of the total number of trips reported. Serious accidents numbered 31 per million bicycle miles. "Falls" are the most frequent crash type, 60% of which are caused by bicyclist error and 40% of which are caused by poorly maintained road surfaces and debris. Falls, considered single-vehicle accidents, account for 43% of all accidents and 38% of serious injuries. Collisions with motor vehicles make up 28% of total accidents requiring medical treatment. Contrary to the supposition that construction of bicycle paths would reduce cyclist injuries and deaths, figures show that 60% of all

serious injuries occur independent from automobile traffic. Less than 18% of total accidents in 1974 were reported to police. Older riders have less overall accidents, while the youngest group (16-25 years) shows a rate of 153.1 collisions or serious falls per million bicycle miles. For accidents requiring medical treatment, the trend is somewhat reversed. Cyclists with more than 10 years of riding experience have 50% less accidents than those with less experience. Utility trips have the highest rate of accident incidence, whereas commute trips have the lowest accident rates. About 65% of respondents rode after dark, either occasionally or frequently. Over 75% rode in the rain. Accident rates in these hazardous conditions are low.

by Jerrold A. Kaplan  
Public Transportation Engineering v47 n7 p40-3 (Jul 1977)  
1977; 2 refs  
Availability: See publication

HS-020 990

# **AUTOMOBILE INSURANCE LOSSES, INJURY COVERAGES: A PRELIMINARY COMPARISON OF RESULTS FROM VOLKSWAGEN RABBITS WITH PASSIVE AND ACTIVE SEAT BELTS, 1975 AND 1976 MODELS**

Frequency of insurance claims for injuries to occupants of 1975 and 1976 model year Volkswagen (VW) Rabbits sold with "passive" and "active" seat belt systems is lower for Rabbits with passive seat belt systems. Passive seat belts are designed to automatically position an upper torso seat belt around front seat occupants without requiring any action by occupants, and lower torso restraint is provided with a fixed knee restraint. Three-point active seat belts require occupants to take action such as buckling and adjusting each time they enter the car. Consequently, a higher percentage of occupants in cars equipped with passive belts are expected to be restrained in crashes than occupants in cars with active belts. For medical payments and personal injury protection coverages, Rabbits with passive belts had substantially lower claim frequencies than those with active belts. Medical payments coverages were 19% reduced, and personal injury protection coverages were 24% reduced. Substantial claim reductions cannot be causally linked with age variations or deductible amount. Average loss payments were virtually identical for both groups. Collision coverage claims with associated injury claims for the two groups of VW Rabbits were 20% reduced for medical payments coverages with passive belts, and 27% reduced under personal injury protection coverages with passive belts. Appendices include specifications of injury coverages, sources and nature of data, and definitions.

Highway Loss Data Inst., Watergate 600, Washington, D.C. 20037  
Rept. No. HLDI-RR-A-8; 1977; 21p  
Availability: Corporate author

HS-020 991

# **CLEVELAND NEIGHBORHOOD ELDERLY TRANSPORTATION DEMONSTRATION PROJECT. FINAL REPORT**

The Cleveland, Ohio, Neighborhood Elderly Transportation (NET) Demonstration Project which ran from Mar 1975 to Jun 1976 gave personalized door-to-door transportation services

for persons 60 years and over within three inner-city neighborhoods. Operations and vehicle maintenance were provided on a daily basis by the Cleveland Transit System for 12 specially designed and equipped buses. Service, obtained by calling a scheduling/dispatching center which rerouted buses to make pick-ups and deliveries, cost 10 cents. Service was provided for both immediate and advance reservation requests. The transportation service was well liked by those who used it, due to its door-to-door service, ease of boarding and leaving bus, special assistance by driver, and inherent personal safety. Many riders shifted from existing fixed route service, although most were capable of using it. NET users tended to be female, have lower incomes, and less automobile mobility than nonusers. More aggressive and able-bodied individuals seemed to utilize the service more often than those needing it more. Service costs rang about \$20 per vehicle-hour and \$4 per passenger. Productivity averaged 6 passengers per "in service" vehicle hour a maximum level ridership. Permanent operation was not feasible due to costs. Cleveland's post-demonstration system raised the age from 60 to 65, limited hours of operation, required 24-hour advance registration, made service free except at peak times, and, most important, negotiated for and introduced a new driver classification at \$4.40 per hour. Appendices include data on riders and nonusers, agency survey analysis, Transit System policy statement, labor agreement, and report of inventions used on special vehicles.

by John Crain  
Crain and Associates, 873 Santa Cruz Ave., Menlo Park, Calif. 94025

Contract DOT-TSC-1081  
Rept. No. UMTA-OH-06-0018-77-1; 1977; 168p  
Part of the UMTA/TSC Proj. Evaluation Series, Service and Methods Demonstration Prog. Rept. for Mar 1975-Apr 1976.  
Availability: NTIS

HS-020 992

# **TRUCK NOISE X. NOISE REDUCTION OPTIONS FOR DIESEL POWERED INTERNATIONAL HARVESTER TRUCKS. VOL. 1. DEVELOPMENT WORK**

Noise reduction option development work as part of the retrofit program has been carried out on two in-service diesel powered International Harvester (IH) trucks: a cab-over model and a conventional model with a baseline exterior noise level of 87 dB(A) each. An exterior noise reduction goal of 83 dB(A) was set. Noise identification techniques were applied to each truck to identify major contributors, after which commercially available source noise reducing components were tested singly and selected based on optimum evaluation. Selected components were then collectively installed on trucks and cumulative performance in the total truck environment checked to verify compliance with noise level goals. The first truck, an IH cab over model COH4070A with an NHC-250 Cummins naturally aspirated in-line 6-cylinder engine, was found to have source noise levels in the exhaust, fan, engine, and intake. Noise was reduced with exhaust mufflers, optimization of fan location, engine block sound panels, and an oil pan enclosure. Selected optimum components for exhaust, fan, and engine provided a 4-5 dB(A) reduction in exterior noise level. Conversion of the naturally aspirated engine to a turbocharged engine reduced total exterior noise by 3 dB(A). The second truck, an IH Fleetstar 2000D with a 6-71N65 Detroit Diesel in-line 6-cylinder scavenged engine with N65 injectors, was found to have source noise levels in the exhaust, fan, engine, and in-

take. Primary exhaust and "Super Stack" mufflers were installed, in addition to a contoured shroud extension for fan coverage, an engine bellypan, fuel tank mounting straps, cumulatively providing a 3-4 dB(A) reduction in exterior noise level. Thirteen appendices present noise data, testing and measurement procedures, and report of invention.

by S. T. Razzacki  
International Harvester Co., Truck Engineering Center, P.O.  
Box 1109, Fort Wayne, Ind. 46801  
Contract DOT-TSC-721-1  
Rept. No. DOT-TSC-OST-76-14,I; 1977; 158p 12refs  
Availability: NTIS

HS-020 993

# **PEDESTRIANS, TWO-WHEELERS AND ROAD SAFETY. A STATISTICAL COMPARISON OF PEDESTRIAN, CYCLIST AND MOPED-RIDER ROAD-TRAFFIC FATALITIES IN THE NETHERLANDS FROM 1968 TO 1972**

Fatal traffic accidents in The Netherlands involving bicyclists, mopeds, and pedestrians are analyzed using age, sex, locality, road type, and time characteristics. Data are based on statistics from the Central Bureau of Statistics, The Netherlands on traffic fatalities from 1968 to 1972. More males than females are involved in all three types of fatal accidents. The 0-9 and 60 years or older age groups represent a high proportion of pedestrian fatalities, males being the principal victims. Pedestrian fatalities occur more frequently inside "built-up" areas than outside, except for the 10-19 age group. The 10-19 and 60 years or older age groups form a high proportion of cyclist fatalities. Cyclist fatalities are about evenly divided between inside and outside built-up areas. Most moped-rider fatalities occur in the 10-19 age group, and are about equally divided between inside and outside built-up areas. The smaller the population of a municipality is, the more pedestrian and two-wheeler fatalities there are per 100,000 inhabitants, and more fatalities occur outside built-up areas than inside. Inside and outside built-up areas, most pedestrian fatalities occur on straight roads, whereas cyclist and moped-rider fatalities are divided between straight roads and intersections. Most two-wheeler and pedestrian fatalities result from collisions with private cars, and secondly with trucks. Pedestrian fatalities occur mainly on Fridays, while cyclist fatalities are more evenly divided over days of the week. Most fatalities of all three types occur between 4:30 P.M. and 8:30 P.M. Pedestrian and cyclist fatalities at dusk and in the dark are mainly in the 60 or older age group. Moped-rider fatalities at those times are mostly in the 10-19 age group. Most common injuries suffered by pedestrians and two-wheelers are head injuries, followed by leg injuries. Tables and graphs of all data used are included.

by J. H. Kraay  
Institute for Road Safety Res., SWOV, P.O. Box 71,  
Deernsstraat 1, Voorburg 2119, The Netherlands  
Rept. No. 1976-3E; 1976; 63p  
Availability: Corporate author

HS-020 994

## **DRINKING AND DRIVING. A LITERATURE STUDY**

A review of statistical research literature on drinking and driving concerns mainly private motor vehicle drivers. The first of

four main literature topics concerns risk of drinking and driving, which has usually been studied by comparing a group of accident-involved drivers with a nonaccident group, blood alcohol concentration (BAC) being the most important research variable. A causal relationship between BAC and accident risk has been established. Research on effects of other driving characteristics on accident risk has proved little. Accident risk and BAC level ratios can be influenced by variables such as age, sex, frequency of drinking, time, and place. Based on current research review, it is not possible to indicate the BAC limit above which it is undesirable to drive for road safety reasons. The second major research topic, drinking-drivers' contribution to road accidents, is inconclusive due to the fact that reliable statistics on frequency and amount of alcohol in relation to fatal accidents are not available. General research findings indicate that accidents involving alcohol are mainly single-vehicle, generally serious, and occur often at night or on the weekends. The third research topic, drinking-drivers' characteristics, analyzes such variables as age, alcoholism, convictions, sex, and overall social conditions. Effectiveness of measures against drinking-driving, the fourth topic of research, varies according to technique used. Statutory BAC limits legislated in Great Britain have had little impact on drinking and accident frequency, after a temporary drop. Statutory BAC limits imposed in Canada, France, and Australia appear to have had less impact than in Great Britain. Punishments or treatments for drunk driving offenders include measures having special deterrent effects, such as probation, detention, or treatment courses; or measures having a general deterrent effect on the group as a whole, such as generalized effects of stiff detention penalties for drunk drivers. Publicity as a countermeasure may be either informational or oriented toward changing public attitudes and behaviors.

by P. C. Noordzij  
Institute for Road Safety Res., SWOV, P.O. Box 71,  
Deernsstraat 1, Voorburg 2119, The Netherlands  
Rept. No. 1976-4E; 1976; 48p 76refs  
Availability: Corporate author

HS-020 995

## **EFFECTIVENESS OF DRIVER EDUCATION: WHAT DO WE KNOW AND WHERE DO WE GO FROM HERE?**

A report on a Canadian study of the absolute effectiveness of driver education deals primarily with methodological considerations critical to evaluation research, and reviews relevant literature. Early studies on driver education effectiveness were of questionable validity due to the fact that they compared training group and control group performance without accounting for characteristics of course participants and measuring instruments used to determine performance. Stated objectives of formal driving instruction each possess inherent methodological problems associated with evaluation. Acquisition of principles of driving, a conceptual element of formal driver instruction, is not clearly enhanced by driver education. Analysis is often contaminated by participant characteristics, for example, a higher level of knowledge of many voluntary enrollees. Development of safe driving attitudes, another conceptual element, is difficult to define and measure. Initial attitudes of students and social desirability are contaminating elements. Studies indicate no significant changes in attitudes following exposure to formal courses. Intermediate criteria (procedural elements of formal driver instruction) are performance of beginning drivers on road tests; virtually no research exists to



evaluate educational effectiveness. Previous driving experience, and that acquired informally during formal instruction, present methodological problems. Ultimate criteria, or effectiveness of driver instruction in reducing crashes and violations of young drivers, present methodological problems of measurement due to characteristics of course participants, use of driver records for data, area of residence, and driving exposure. Preliminary results indicate no differences between formally and informally trained drivers. Recommendations state that further research should be curtailed until results of ongoing studies are available; and that plans for expansion of formal driving instruction programs should be carefully scrutinized. Proposals for substantive curriculum changes should be viewed as pilot programs and accompanied by independent effectiveness evaluation. Pilot research should be initiated to determine the feasibility and practicality of "error-analysis" research. Appendices present summary tables of evaluation research and recent fatality statistics on young drivers. An annotated bibliography is included.

by L. Page-Valin; H. M. Simpson; R. A. Warren  
Traffic Injury Res. Foundation of Canada, 1765 St. Laurent Blvd., Ottawa, Ontario K1G 3V4, Canada  
1977; 103p 188refs  
Availability: Corporate author

HS-020 996

## ARIZONA TRAFFIC ACCIDENT SUMMARY

A 1976 tabulated Arizona traffic accident summary shows deaths up by 69 to 737 as compared with 1975. Tables present Arizona accident statistics for each year from 1925 to 1972. Accident data for 1976 are compared with 1975. Tables are included on seatbelt usage; accident involvement by registered vehicles and licensed drivers; Arizona economic losses; and nationwide accident facts. Tabulated data are presented on locations, times, and types of accidents; motorcycle accidents; and pickup and other truck accidents. Age distribution and characteristics of accident-involved drivers are included, as well as information on pedestrian accidents. Accidents are reported according to light and weather conditions, and road conditions and characteristics. Information on school bus accidents is included. The 1976 annual record shows that one person was killed every 11.9 hours, one person being injured every 13.3 minutes. Injured pedestrians numbered 1,018 (13.5% had been drinking), with 156 pedestrian deaths (of which 29.5% had been drinking). Motorcyclist injuries numbered 2,807, and there were 48 deaths. Bicyclist injuries and deaths were 956 and 17, respectively. Of 1,373,811 licensed drivers, approximately 1 out of 20 were involved in an accident in 1976. Male drivers were involved in 64.2% of all accidents and 75.8% of fatal crashes. Drinking drivers were involved in 13.4% of all accidents and 29% of fatal crashes. One vehicle out of every 12.3 was involved in an accident. Of all accidents, 71.1% occurred in daylight hours. Of all fatal accidents, 31% occurred on Saturday and Sunday. Friday proved the most dangerous day, with 19% of all accidents. The annual economic loss to every Arizona citizen was \$130. Of the 737 persons killed, 19% were from out-of-state, as were 12% of drivers involved in fatal accidents.

Arizona Dept. of Transportation, Office of Hwy. Safety  
1976; 33p  
Availability: Corporate author

HS-020 997

## BLOOD ALCOHOL LEVELS AND DRINKING BEHAVIOUR OF ROAD CRASH VICTIMS

Social characteristics and drinking patterns of persons brought to a Canadian hospital emergency department after a car crash are correlated with their blood alcohol levels (BAC's) for 1,050 persons during a nine-month period. BAC's were known, and personal data were obtained from hospital records and 228 interviews. One quarter of subjects had positive BAC's, 21.6% exceeded the legal limit of 0.05 gm%, and one tenth exceeded 0.150 gm%, which is considered presumptive evidence of a drinking problem. Sex was the personal variable having the most marked association with BAC: 90% of subjects above 0.150 gm% were males. Although 60% of the sample was less than 30 years old, age, marital status, and social ranking of suburb were not associated with increasing BAC. Those born in eastern Europe and of Jewish or Greek Orthodox religions were markedly underrepresented in the BAC positive group. Skilled workers were slightly overrepresented. The BAC positive group had more single vehicle crashes, and more weekend crashes occurring between 9 P.M. and 3 A.M. Those with higher BAC tended to have more severe injuries, particularly of the head. About half of the subjects with positive BAC underestimated their intake by about 50%. Compared with a

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Study results indicate  
after a crash is a fairly  
potential drinking problems.  
pendices, and the Michigan  
in this study, is included.

by G. Anthony Ryan; Wendy E. Salter  
Monash Univ., Dept. of Social and Preventive Medicine,  
Prahran, 3181, Victoria, Canada  
1977; 62p 13refs  
Availability: Corporate author

HS-020 998

## DETERMINING THE COEFFICIENT OF FRICTION

Using the coefficient of friction for stopping ability, a close estimate of speed involved in an accident can be determined, which can then be used as evidence in legal proceedings. Coefficients of friction, based on measurements of skidmarks, do not appear to be affected by vehicle weight. The coefficient is a measurement of the ability of opposing forces (usually skidding tires) to decelerate a vehicle compared to the ability of gravity to accelerate a falling object in the absence of atmospheric resistance; it can exceed 1.0. Speed loss from skidding is determined by measuring the longest skidmark, calculating coefficient of friction, and inserting figures into a simple formula. Because engineering tests on road surfaces can result in far different coefficients of friction than actual vehicle skids, they should not be used for present estimation purposes. Theoretical reference charts or insurance company charts should not be used because they are intended only as probabilities. The best, although not absolutely accurate method for determining coefficient of friction is the test skid, which could be legally considered a search. The test would

consist of seeing how long a skidmark can possibly be produced by skidding the same vehicle to a stop at a known speed. Circumstances encountered in the accident skid should be duplicated as nearly as possible, which is most easily achieved by conducting the test at the accident site. Roadway surface, grade or slope, atmospheric temperature, tire tread, humidity, wind direction and velocity, length of skid, and tire inflation should all be considered in making calculations. Lengths of visible marks vary depending on characteristics of tires. Types and conditions of braking systems also affect overall stopping distance and length of visible skidmarks, requiring adjustments in calculations. The four-drum arrangement results in long visible skidmarks and long braking distance. Two-disc and four-disc arrangements result in widely varying stopping distances and skidmarks. Temperature and age of brakes as well as physical strength of driver should be taken into account.

by H. Wayne Overson

Publ: Highway Patrolman v41 n5 p12-4, 35, 37-8 (Jul 1977)

1977

Availability: See publication

HS-020 999

#### UNCERTAINTIES IN ESTIMATES OF FLEET AVERAGE FUEL ECONOMY: A STATISTICAL EVALUATION. FINAL REPORT

The current Federal procedure for estimating average fuel economy of automobile manufacturers' new car fleets cannot determine average fuel economy to within 0.1 mpg, the increment to be used in specifying financial penalties and credits to manufacturers under the Energy Policy and Conservation Act. Stratified random sampling is deemed a more appropriate approach for estimating fleet average fuel consumption than simple random sampling; this would call for subdivision into classes of new cars with similar engineering and design parameters. However, inherent sources of error include differences in same-vehicle repeated tests due to physical variations among same-class vehicles. The ratio of standard deviation to mean fuel economy probably ranges from 5% to 9%, although quantitative error estimates are very uncertain. EPA fuel economy estimates use the stratified sampling approach, disadvantaged by nonrandom sampling within vehicle classes. To ensure accuracy of existing measurement techniques sample size would have to be drastically increased. Recommendations suggest randomized representation of optional equipment within vehicle classes, along with optimal fleet stratification procedures. Further study is necessary to quantify fuel economy variability and its relationship to test and laboratory procedures and equipment, production processes, and vehicle parameters. A cost-benefit analysis should be performed prior to any increase in sample size.

by F. T. Rabe

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Contract DOT-TSC-1311

Rept. No. DOT-TSC-OST-77-32; 1977; 63p 9refs

Rept. for Nov 1975-Nov 1976.

Availability: NTIS

HS-021 000

#### EFFECTIVENESS OF WORKSHOPS ON MANAGEMENT EVALUATION OF TRAFFIC SAFETY PROGRAMS. FINAL REPORT

Nine NHTSA Office of Manpower Development workshops on management evaluation of traffic safety programs, held in various cities throughout the U.S., are evaluated to determine their effects on knowledge of attendees. Pretests and posttests, termed "interest surveys," were administered to 160 highway safety administrators at beginning and end of each workshop. Some increased knowledge of the materials taught was evidenced, although up to 78% of participants in one workshop had the same pretest and posttest scores. Conclusions are limited due to difficulties in interworkshop comparisons, ambiguity of test items, and self-selection in test taking. Uncontrolled factors which could have influenced results include location, instructor, background of attendee, and material taught. Many respondents learned how to state project objectives, whereas few learned how to anticipate problems in data collection. Appendices present the original questionnaire used in five workshops; a revised questionnaire used in four workshops; and item analysis by workshop.

by Cheryl Lynn; Deborah Mitchell

Highway Safety Div. of Virginia, Virginia Hwy. and

Transportation Res. Council, Charlottesville, Va.

Rept. No. VHTRC-77-R61; 1977; 30p 3refs

Availability: Corporate author

HS-021 001

#### RAILROAD-HIGHWAY CROSSINGS, VISIBILITY, AND HUMAN FACTORS

A collection of 12 articles provides research reports on accident incidence at railroad highway crossings, effects of luminance and contrast on visibility, and human factors in highway safety. Report is made on field research on the applicability of laboratory threshold visibility data in predicting seeing distances to stand-up and road-surface targets by use of different headlight beam patterns. A laboratory study of sign legibility shows that a contrast of 30% to 50% is required to maintain 75th percentile legibility. The use of high-intensity sheeting on overhead highway signs is deemed feasible for sign illumination without external lighting. As part of a comprehensive program to explore driver-vehicle system response in lateral steering tasks, describing functions and dynamic data have been gathered in several milieus. Installation of flashing light signals and automatic crossing gates has reduced frequency and severity of vehicle-train accidents in California. Statistical techniques are tested on results of investigations of railroad-highway accidents and accident-related inventory information collected from 15 states and three railroad companies, used for development of accident prediction equations and severity prediction rates.

National Academy of Sciences, Transportation Res. Board.

Commission on Sociotechnical Systems, National Res.

Council, Washington, D.C.

Rept. No. TRR-611; 1976; 74p 87rcfs

Availability: Corporate author

distances to stand-up and road-surface targets by use of different head-light beam patterns. Tests were conducted using a vehicle equipped with a precision odometer system to measure detection distances of 12 subjects under different target-background-glare conditions. Subject testing was followed by extensive photometry to measure the target, background, and veiling brightness of each target condition. Reflectance properties of the pavement and road shoulder were also mapped. Detection distances are predicted from directly measured brightness and brightness computed from target and background reflectance data, ambient brightness, and assumed head-lamp beam patterns. A comparison of field-observed and predicted seeing distances shows good to excellent agreement. Laboratory brightness contrast detection threshold data are applicable in predicting seeing distances of alerted drivers to vertical targets under night-driving situations, and, to a lesser degree, to horizontal targets. The Blackwell model along with Fry's veiling glare formula to account for disability glare can predict seeing distances to targets under opposed glare situations when glare angles are larger than  $0.75^\circ$ . For smaller glare angles, a contrast multiplier of about 30 appears appropriate for seeing-distance prediction under high-beam situations. Seeing distance to targets under any head-lighting beam can be analytically predicted with sufficiently good accuracy from headlamp characteristics, photometric/geometric roadway characteristics, driver characteristics, target characteristics, and laboratory brightness contrast threshold data.

by Vivek D. Bhise; Eugene I. Farber; Paul B. McMahon  
Ford Motor Co., Environmental and Safety Res. Office;  
Federal Hwy. Administration  
Publ: HS-021 001 (TRR-611), "Railroad-Highway Crossings,  
Visibility, and Human Factors," Washington, D.C., 1976 p1-16  
1976; 31refs  
Availability: In HS-021 001

HS-021 003

#### **LUMINANCE AND CONTRAST FOR SIGN LEGIBILITY AND COLOR RECOGNITION**

A laboratory study of sign legibility shows that a contrast of 30% to 50% is required to maintain 75th percentile legibility. 1. Legibility distance increased gradually with greater contrast to about 80%; above a luminance ratio of 5 to 1, legibility did not increase greatly. As ambient levels increased, legibility distance increased linearly with the logarithm of either the letter or the sign luminance, whichever was greater. Five color combinations were measured, and effects of luminance and contrast to legibility distance for 11 color combinations, correcting for letter and stroke width showed legibility to be lowest at a 50% to 60% contrast (legend to sign). Above an 80% contrast, legibility leveled off for each color combination and ambient background level. Effects of luminance and contrast on color recognition at five ambient levels indicates a need to increase luminance and contrast as ambient levels increase. Laboratory luminance data, confirmed by two sets of outdoor measurements, provide a basis for determining the luminance ratios used in legibility estimates. A method developed for estimating glance and ordinary or static legibility

Availability: In HS-021 001

HS-021 004

#### **EVALUATION OF HIGH-INTENSITY SHEETING FOR OVERHEAD HIGHWAY SIGNS**

The use of high-intensity sheeting on overhead highway signs is deemed feasible for sign illumination without external lighting. Brightness of five high-intensity overhead signs without illumination is compared with that of five conventional signs with illumination. Experiments were conducted in the field under physical and environmental conditions experienced by the highway user. Luminance measurements were made with a telephotometer at the driver's eye position in 11 domestic automobiles. A total of 4821 luminance measurements were recorded from travel lanes of illuminated and nonilluminated roadways. On nonilluminated straight roadways no statistical differences were noted in brightness of background materials for the two types of signs seen by motorists traveling in stream traffic. On a curved approach, when only a limited amount of light from vehicles was projected onto overhead signs, luminances of unlighted high intensity materials were not sufficient to provide motorists with equivalent sign legibility and visibility obtained from conventional signs. Presence of roadway lighting reduces the maximum visibility distance and thus increases the probability that a sign will not be seen even though the legibility distance may be adequate. Thus, conclusions indicate that external lighting can be eliminated on many overhead signs through the use of high-intensity sheeting without adversely affecting service to motorists.

by R. N. Robertson  
Virginia Hwy. and Transportation Res. Council  
Publ: HS-021 001 (TRR-611), "Railroad-Highway Crossings,  
Visibility, and Human Factors," Washington, D.C., 1976 p28-34  
1976; 8refs  
Availability: In HS-021 001

HS-021 005

#### **OVERHEAD SIGNS WITHOUT EXTERNAL ILLUMINATION**

High intensity reflective sheeting for use on overhead sign installations without external illumination is evaluated and judged practical for sign illumination. Effects of height above the roadway and angle of sign tilt with respect to the vertical, headlight configuration, and vehicle approach speed to sign legibility distance were measured for both an externally illuminated sign and a high-intensity reflective sheeting sign. The nighttime legibility distance of overhead signs was not appreciably affected by increases in mounting height in the range of 5.5 to 7.0 m, by changes in angle of the sign with respect to the vertical in the range of  $-5^\circ$  to  $05^\circ$ , or by vehicle approach speed. Headlight configuration, as expected, was the dominant

by Donald L. Woods; Neilon J. Rowan  
Texas Transportation Inst.  
Publ: HS-021 001 (TRR-611), "Railroad-Highway Crossings,  
Visibility, and Human Factors," Washington, D.C., 1976 p38-  
44

1976; 5refs  
Availability: In HS-021 001

HS-021 006

#### **COMPARISON OF DRIVER DYNAMICS WITH ACTUAL AND SIMULATED VISUAL DISPLAYS**

As part of a comprehensive program to explore driver-vehicle system response in lateral steering tasks, describing functions and dynamic data have been gathered in several milieus. These milieus include a simple fixed-base simulator with only an elementary roadway delineation display; a fixed-base statically operating automobile with terrain displayed by a wide-angle projection system; and a full-scale moving-base automobile operating on the road. Dynamic data with the two fixed-base simulators compares favorably and implies that the impoverished visual scene, lack of engine noise, and simplified steering wheel characteristics in the simple simulator do not induce significant driver dynamic behavior variations. The fixed-base versus moving-base comparisons show that the moving base has substantially greater crossover frequencies on the road course; this frequency can be ascribed primarily to a decrease in the driver's effective latency. When considered with previous data, the moving-base full-scale versus fixed-base simulator differences are ascribed primarily to the motion cues present on the road course rather than to any visual field differences.

by Duane T. McRuer; Richard H. Klein  
Systems Technology, Inc., Hawthorne, Calif.  
Publ: HS-021 001 (TRR-611), "Railroad-Highway Crossings,  
Visibility, and Human Factors," Washington, D.C., 1976 p46-8  
1976; 9refs  
Availability: In HS-021 001

HS-021 007

#### **EFFECTIVENESS OF AUTOMATIC WARNING DEVICES IN REDUCING ACCIDENTS AT GRADE CROSSINGS**

Installation of flashing light signals and automatic crossing gates, promoted by the California Public Utilities Commission and State Legislature, has reduced the frequency and severity of vehicle-train accidents. To determine the effectiveness of automatic warning devices under varying conditions, the before-and-after accident histories at 1552 grade crossings where automatic devices were installed between 1960 and 1970 were compared on a crossing-year basis and segregated by type of warning device, rural versus urban conditions, and number of railroad tracks. Installation of automatic gates can be expected to reduce vehicle-train accidents by approximately 70% per crossing-year and to reduce related deaths and injuries by 89%

percentage reduction in all accident and casualty rates was higher at rural crossings. Double-track main or branch crossings were more prone to accidents than single-track, and showed the greatest benefit in terms of numbers of accidents and casualties reduced. Automatic gates are superior to other types of warning devices because they have a visual and auditory impact on driver response.

by William R. Schulte  
California Public Utilities Commission, San Francisco, Calif.  
Publ: HS-021 001 (TRR-611), "Railroad-Highway Crossings,  
Visibility, and Human Factors," Washington, D.C., 1976 p49-57  
1976; 6refs  
Availability: In HS-021 001

HS-021 008

#### **INVESTIGATION OF ACCIDENT DATA FOR RAILROAD-HIGHWAY GRADE CROSSINGS**

Mathematical analysis techniques are tested on results of investigations of railroad highway accidents and accident-related inventory information which was collected from 15 states and three railroad companies. Statistical techniques are applied to tabulated data to obtain prediction equations for accident frequency and severity of various grade-crossing situations. The ratio of number of accidents for a group of crossings to the number of crossing-years of exposure has evolved as a measure of the accident potential for a group of crossings. Accident severity equations and accident severity prediction rates, used in development of economic warrants and priorities for safety improvements, are part of a program to reduce number of accidents and degree of accident severity at railroad-highway grade crossings. Development of accident prediction equations has focused on the relationship between observed accident rates for groups of crossings with similar physical characteristics and the associated average daily train and vehicle volumes. For the sample data base, 70% was randomly selected for testing alternative models of multiple linear regression, and the remaining data were reserved for validation purposes. The purpose of the statistical severity analysis was to explain the structure of the relationship between differences in severity rates for different groups of accidents. Expected number of fatalities and injuries that would result from a group of similar accidents may be viewed as the product of the rate of injury/fatality per accident and the number of accidents for which the rate applies. Accident prediction equations and severity prediction rates can be applied to the study of potential accident experience for groups of crossings over a certain period of time.

by Janet Coleman; Gerald R. Stewart  
Federal Hwy. Administration  
Publ: HS-021 001 (TRR-611), "Railroad-Highway Crossings,  
Visibility, and Human Factors," Washington, D.C., 1976 p60-7  
1976; 13refs  
Availability: In HS-021 001

were taken on a sample of 4127 infants, children and youths representing the U.S. population aged 2 weeks through 18 years. Measurements were taken throughout the U.S. by two teams of anthropometrists using an automated anthropometric data acquisition system. Standard anthropometers, calipers, and tape devices were modified to read electronically and input dimensional data directly to a minicomputer for data processing and storage. Summary statistics of measurement results are reported for 16 age groups along with scatter plots of the data points for the sexes combined and males and females separately. Each measurement is described along with a photograph and illustration. In addition bivariate relationships of selected functional measurements with weight or stature are provided along with regression data. An appendix shows measurement locations by geographic area.

by Richard G. Snyder; Lawrence W. Schneider; Clyde L. Owings; Herbert M. Reynolds; D. Henry Golomb; M. Anthony Schork

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Contract CPSC-C-75-0068

Rept. No. UM-HSRL-77-17; 1977; 619p 99refs

Rept. for Apr 1975-Apr 1977.

Availability: Corporate author

HS-021 010

## ANALYSIS AND SUMMARY OF ACCIDENT INVESTIGATIONS 1973-1976

Accident experience of commercial motor carriers is tabulated and evaluated for the purpose of determining specific problem areas, accidents of a recurring nature, violations of the Federal Motor Carrier Safety Regulations, and the need for strengthened or additional safety regulations. Based on a four-year study, analytical data are provided covering types of accidents in direct relationship to human, vehicle, and environmental factors. A total of 497 accidents, which resulted in 783 fatalities, 1,651 injuries, and \$23,405,075 property damage, were investigated by Bureau of Motor Carrier Safety field staff and are summarized in tabular format. Summaries of accident investigations are presented in narrative form separately for each year. Probable cause and contributing factors, identified in each accident summary, are most often deemed chargeable to the motor carrier's vehicle and/or driver. Data are broken down by accident type; collision sequence -- vehicles involved; single vehicle accidents; year of manufacture by type of cab; and type of commodity/operation by type of accident. Tables are included for ambience of human factor accidents; driver's age and experience by accident type; accidents involving hazardous materials; and mechanical defect accidents. Also tabulated are truck and bus skidding accidents; truck and bus occupant ejections; environmental factors by accident type; and accident location by region and state.

Federal Hwy. Administration, Bureau of Motor Carrier Safety, Washington, D.C.

1976; 166p

Availability: Corporate author

Third-year results are reported for a three-year research program to conceive and evaluate practical ways of increasing automobile fuel economy by energy management within the engine-transmission-vehicle system. During the third year a Flywheel Energy Management Powerplant (FEMP) was designed, constructed, and installed in a Pinto for verification of performance simulation. The FEMP consists of an internal combustion engine, a high-speed energy-storage flywheel, and hydrostatic power-split continuously-variable transmission (CVT) system. The flywheel drives the car, and the engine comes on to "recharge" it (with efficient wide-open throttle operation) only when the flywheel speed drops below a predetermined value. The concept permits effective and efficient regenerative braking. Computer simulations have indicated an improvement in city fuel mileage of about 50%, with improvements of 100% appearing feasible with further research. Preliminary testing shows favorable performance. Good positive control is achieved with the torque control system. The on-off method of engine control, although satisfactory for improving engine efficiency, has a problematic high noise levels, which can probably be controlled by noise-abatement techniques.

by N. H. Beachley; A. A. Frank

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Contract DOT-OS-30112-Mod 3

Rept. No. DOT-TST-77-21; 1976; 90p 8refs

Rept. for 1 May-1 Jul 1976.

Availability: NTIS

HS-021 012

## ECONOMIC IMPACT OF HIGHWAY SNOW AND ICE CONTROL. STATE-OF-THE-ART. INTERIM REPORT

The economics of highway snow and ice control are examined as they relate to maintenance, traffic, safety, environment, roadway damage, vehicle corrosion, structural deterioration, and economic analysis. Snow and ice control as a maintenance operation differs greatly from state to state, in terms of public relations, public opinion, and sovereign immunity. Procedures and policies such as levels of service, budgeting, productivity, and contract maintenance are program components. Chain laws, snow fences, roadway design considerations, and weather forecasting and communications also depend partly on economic considerations. Materials usage has increased drastically in past years: chemicals, abrasives, alternatives (and their storage, stockpiling, rate of application) must be planned for. Safety methods for equipment, routing, and maintenance of bridge decks must be specially planned. Maintenance equipment and personnel vary depending on requirements of the area and budget. Economic impact of ice and snow on traffic safety involves reduced volumes, fuel consumption, delay, tardiness, and comfort and convenience. Environmental issues center on effects of de-icing salts on land, atmosphere, water, plants, and animals. Roadway damage often affects paint stripes, raised pavement markers, rumble strips, and delineator posts. Vehicle corrosion and structural deterioration are often extensive in snow and ice conditions: water, chlorides, design-related mechanisms, joint design, and construction af

feet presence and rate of deterioration. Appendices present 1975 snow and ice program standards by state; sodium chloride specifications for the Utah Dept. of Highways; selected state snow and ice practices; and salt tolerances of trees and shrubs. A word index is included.

by Bob H. Welch, et al.  
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Contract DOT-FH-11-8580  
Rept. No. FHWA-RD-77-20; UDOT-MR-76-7; 1976; 295p  
428refs  
Availability: NTIS

HS-021 013

### FUEL AND LUBRICANT COMPOSITION EFFECTS ON ARMY TWO-CYCLE DIESEL ENGINE PERFORMANCE

A high-output Army two-cycle diesel engine is subjected to proving-ground related laboratory-dynamometer endurance test cycles using four different qualified MIL-L-2104C SAE grade 30 lubricants. Three diesel fuels differing mainly in sulfur level and end point temperature are an important part of the test matrix. Two lubricants (low-ash and mid-ash level) produce acceptable performance and a third (of high-ash level) is considered borderline acceptable; all during operation with reference No. 2 diesel fuel (0.42% weight sulfur). A fourth oil (low-ash level) is judged to be incompatible due to its proneness to severe piston and liner scuffing. The engine is judged incompatible with a high sulfur/high end-point fuel intended to meet MIL-F-16884F (Marine Diesel Fuel) using two different MIL-L-2104C lubricants. This engine is also judged to be incompatible with a special blend of NATO F-54 diesel fuel (0.64% sulfur) during operation with the same two lubricants. Incompatibility using fuel sulfur levels greater than 0.50% is based on the occurrence of catastrophic piston/ring/exhaust valve failure and relatively high deposit and wear levels. An appendix summarizes engine endurance test procedures.

by Sidney J. Lestz; Maurice E. LePera; Thomas C. Bowen  
U.S. Army Fuels and Lubricants Res. Lab., Southwest Res.  
Inst.; U.S. Army Mobility Equipment, Res. and Devel.  
Command  
Rept. No. SAE-760717; 1976; 30p 34refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 014

### FINITE ELEMENT ANALYSIS OF A CARRIER FRAME

A finite element model of the carrier frame of a rubber-tired mobile crane, analyzed, compared, and verified with actual test results, can be used to try new design ideas and remove weight from the structure without increasing stress levels. The model predicts a stress concentration area where the bogie bracket is welded to the carrier frame. The analysis model was developed using MSC/NASTRAN finite element program on the A. O. Smith 370/165 computer. Strain gauges were used to measure stress levels in critical areas determined by NAS-TRAN stress analysis. The mobile crane has a lifting capacity of 140 tons, capable of traveling 40-45 mph between job sites and at a slow "creep" speed on-site. Most lifts are made with the machine supported on its outriggers; which are fabricated

steel beams which extend from the machine's sides to provide it with a solid and level working base. The crane's turret top of the frame must remain relatively flat in a fully loaded condition to insure free rotation of the upper superstructure. A field test, conducted with seven strain gauges located at the centroid of elements showing the highest equivalent stresses had the machine supported on its outriggers and a load of 280,000 lbs was lifted 12 ft over the right rear corner of the machine. Before the test, the load was lifted and swung over the rear corner several times to relieve residual stresses resulting from fabrication. The upper superstructure was removed from the corner frame and strain gauges were set to zero. Field results are generally lower than those predicted with NASTRAN, but, on the average, are within 10% of predicted values. Further investigation of a more flexible attachment of the bogie brackets is warranted. The carrier frame model shows that no excessive turret top deformation occurs during loading. An appendix outlines MSC/NASTRAN features used in the carrier frame model.

by Thomas E. McHugh; Vern D. Overbye  
Harnischfeger Corp.; A. O. Smith Corp.  
Rept. No. SAE-760640; 1976; 8p 7refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, Wis.  
13-16 Sep 1976.  
Availability: SAE

HS-021 015

### "BUCKLING" FAILURE ASSESSMENT FOR LONG CYLINDERS

A new method for the structural study of long hydraulic cylinders, called structure analysis of regular hydraulic cylinders (SACREG), takes cognizance of most known conditions and disturbances, and is capable of an iterative type solution by computer. It can be used to evaluate the effects of stroke length and mounting position on stresses, deflections, internal bearing loads, and critical axial load. The basic equation used in the analysis relates the bending moment at any cross-section of a straight elastic beam, to its curvature. The bending moment at any section can be written in terms of the external axial loads and their eccentricities, external couples, and traverse loads. Once the deflection curve is established, the next step is to calculate the maximum deflections and the location and magnitude of the maximum stresses. The design problem is usually the determination of the maximum safe load for a given set of geometrical features and material properties. Eight factors are included in the mathematical formulation: clearances at piston head and gland; compressibility of seals and bearings; eccentricity of axial load; and self-weight of cylinder and rod. Other factors are: friction at supporting pins; support locations and end conditions; use of solid, hollow, and pressurized rods; and use of stop tubes. The computer solution program, written in ANSI standard FORTRAN IV, is coded to allow maximum flexibility. The SACREG method and program have been used experimentally for a construction machinery hydraulic cylinder, a long stroke cylinder with a high slenderness ratio, and a drill rig feed cylinder. Further verification studies are necessary to confirm usefulness of the method.

by John T. Parrett; S. K. R. Iyengar  
Koehring Co., Benton Harbor Engineering Div.; Oklahoma  
State Univ., Fluid Power Res. Center  
Rept. No. SAE-760641; 1976; 10p 8refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, Wis.  
13-16 Sep 1976.  
Availability: SAE

HS-021 016

## ELECTRODEPOSITED COATINGS OF CYLINDER BORES FOR SMALL ALUMINUM ENGINES

Surfaces used in cylinder bores of small aluminum engines, such as the iron liner, the chrome plated cylinder, the nickel-silicon carbide composites, the Reynolds 390 aluminum alloy, and aluminum cylinders with chrome plated pistons, are critical in small engine performance and cost. Composite plating such as nickel silicon carbide appears to be the best electrodeposit for cylinders, but it is the most expensive in prototype cylinder plating. The chromium plated cylinder bore with the proper finish, geometry and deposit is almost equal to the nickel silicon carbide bore. The iron liner makes a good cylinder bore if the design is simple, but in many instances in two-cycle engines, it is nearly impossible to use because of complications of the cylinder porting. The 390 alloy encounters difficulties with economics and abuse factor. The Briggs and Stratton or Tecumseh approach of using a standard 360 or 380 aluminum alloy with chromium plated pistons produces a relatively reliable product for small engine purposes when engine demands for performance and life are not critical.

by Stanley Jacoby  
Superior Tihon Plating Co.  
Rept. No. SAE-760646; 1976; 15p 12refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, Wisc., 13-16 Sep 1976.  
Availability: SAE

HS-021 017

## TIRES AND TRACKS IN AGRICULTURE

Relative performance characteristics comparisons of tires and tracks in agricultural soil conditions indicate a trend toward four-wheel drive tractors in the agricultural market. Tracks, which have been used rather than wheel tractors under conditions which require high drawbar pulls over extended periods of time, are recently being replaced by large four-wheel drive tractors, U.S. sales of which have tripled from 1971 to 1975. Several factors contribute to this conversion, the first being a 22% higher productivity of the four-wheel drive tractor compared with a similar weighted track layer in a firm soil. This is due to a higher axle power of the four-wheel drive tractor. A track layer should outproduce a four-wheel drive of equal axle power (with proper weight-to-power) by 12%. A four-wheel drive tractor was found to have a 36%-50% higher productivity than a similar weighted track layer in sugarcane conditions for several tillage operations. For similar weighted tractors, owning and operating costs per hectare for a four-wheel drive tractor are 33% less than that for a track layer. No significant differences in soil compaction between crawler and four-wheel drive tractors were found in field experiments. There was no significant compaction below the tillage zone for both tractors. Theoretical predictions agree well with field experiments.

by W. W. Brixius; F. M. Zoz  
Deere and Co., Moline, Ill.; John Deere Product Engineering Center, Waterloo, Iowa  
Rept. No. SAE-760653; 1976; 13p 6refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, Wisc., 13-16 Sep 1976.  
Availability: SAE

HS-021 018

## PROPORTIONAL BRAKING FOR LARGE TRUCKS IN MOUNTAIN MINE SERVICE--SOME ASPECTS OF DESIGN

Proportional braking on large electric-drive trucks used for downhaul operations in mountain mines was investigated. Trucks used in this type of service are rear dump trucks having payloads ranging from 80 to 350 tons and a corresponding gross vehicle weight of one and a half to two times payload. On these trucks mechanical service brakes are provided on both front and rear wheel sets. They may be either disc or drum brakes actuated by a hydraulic/pneumatic system. On some trucks provision is made for the brake effort on the front wheel sets to be reduced at the discretion of the driver. This proportional braking is intended to minimize the possibility of front wheel skidding on icy roads with consequent loss of steering. However, this voluntary reduction in front wheel braking seriously impairs the braking capacity of the truck. For typical loaded truck geometries in present use, the rear wheels will always slip first. Therefore, with present front and rear brake proportions any reduction in front wheel braking appears unjustifiable if the objective is to eliminate the possibility of front wheel slip before the rear wheel starts to slip. Other research is cited which shows that reduced front wheel braking reduces the available braking capacity to such a degree as to hazard the safety of the vehicle. For future designs of vehicles intended for loaded downhaul operation, it is suggested that attention might be given to increasing the braking capacity on the front wheels, if increased stopping capability is required. Design charts are included for critical slip conditions for road grades up to 20% for different road/tire interface coefficients of friction for a range of vehicle deceleration rates.

by G. Walker; A. G. Doige  
Department of Mechanical Engineering of Calgary, Alta., Canada  
Rept. No. SAE-760655; 1976; 11p 2refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
Availability: SAE

HS-021 019

## PARAMETERS AFFECTING THE DAMPING PRODUCED BY A SEPTUM-LOADED FIBROUS BLANKET

The long-accepted test method for determining relative damping, the Geiger Thick Plate Test, was expanded and modified to observe how damping of a septum-loaded fibrous blanket varies when physical parameters affecting the loading septum are changed and when physical parameters affecting the fibrous blanket are changed. The following parameters were investigated in relation to performance of the loading septum: type of material (in this study, Mastic, fairly stiff material with the ability to retain a deformation) and Baryform (quite limp material with rubberlike characteristics and a high resistance to deformation), weight of material, temperature, position, and adhesion. With respect to the fibrous blanket, the following parameters were studied: type of material (Tufflex, Amberlite, jute, fiberglass, and foam), adhesion, position, and plate size (frequency). Of the parameters considered, the mass of the loading septum, adhesion and type of spacer material were observed to be the most influential in altering the damping produced by a septum-blanket combination. One parameter

that appears to have a direct relationship to damping is the mass of the loading system; adding mass to the loading septum improves the damping characteristics of the blanket-septum combination. The type of spacer material and method of adhesion seem to be interrelated and must be considered on an individual combination basis. With certain spacer materials (Baryform/Tufflex, Baryform/Amberlite), the best damping performance was achieved by totally adhering the loading septum to the fibrous blanket which is in turn totally adhered to the vibrating surface. With other materials (Baryform/jute, Baryform/fiberglass), this total adhesion degrades the damping performance or has little effect. The blanket-septum combinations were extremely sensitive to frequency variations between 80 Hz to 1,200 Hz. Generally speaking, as frequency increased, combined loss factor decreased. The blanket-septum combinations were observed to be fairly insensitive to temperature variations between 40° F and 140° F. The sensitivity of the blanket-septum combination to variations in position was dependent upon the type of blanket used and the adhesion. Generally, a totally adhered combination was insensitive to position. When the fibrous blanket was not adhered to the vibrating plate, a change in attitude from the horizontal to vertical position caused a decrease in the normal force and generally resulted in a decrease in damping.

by Thomas W. Kozyra  
H. L. Blachford, Inc.  
Rept. No. SAE-760659; 1976; 14p 4refs  
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HS-021 020

## PLASTIC MATERIALS SELECTION GUIDE

A technique to guide users in selecting plastic materials includes the following three steps: application screening, generic family and specific grade identification, and process selection and cost analysis. The screening process is accomplished by developing a set of simple functional requirements which the component should meet, determining the component category, and evaluating the component requirements against an End Use Requirement Check List. When establishing component functional requirements, consideration is given to the following factors: structural, performance, environmental, design criteria, economics factors, and manufacturing processes. The component categories are based on like type applications which typically use similar types of plastic materials. In determining generic family and specific grade identification, the following procedures are followed: listing of all requirements of component on an Analysis of Application Requirements form (tables and tests provided to aid in determining certain properties), using bar charts (Flexural Modulus, Resistance to Heat, Compressive Strength, Tensile Strength, Izod Impact Strength at 73° F, Coefficient of Friction, PV (Pressure x Velocity), Dry and a Qualitative Material Environmental Ratings table to match the properties of various plastics families against the Application Requirements form, tabulating the matches from charts on Work Sheet for Selecting Material Family, tabulating and rating data from Environmental Ratings table. In those instances where a designer is unable to establish specific material requirements, a Qualitative Selection Chart is used to determine those materials which fit certain categories of toughness, strength, and flexibility. Once the best generic family or families have been identified, it is necessary to make a further sort into subgroups which is accomplished by reviewing the data bank in the Modern Plastics Encyclopedia. Once the specific

subgroups have been identified, material supplier literature is searched to determine specific grades which meet the requirements. The third and remaining step of the selection process establishes the most logical method(s) of fabrication and the relative tooling and molding costs. It is necessary to establish which materials and shapes (Shape Classification table) fit certain processes (Molding Processes Applicable to Plastic Materials table). Finally, a Process and Tooling chart is consulted which provides information on methods of fabrication and relative tooling and molding costs.

by Paul F. Kusy  
Deere and Co., Materials Applications Dept., Moline, Ill.  
Rept. No. SAE-760663; 1976; 34p 6refs  
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## LOW MAINTENANCE NOMEX/TEFLON FABRIC COMPOSITE BEARINGS

Selflubricating composite bearings (Fafcon CJ Composite Journal Bearings) have been developed which have proven effective in reducing maintenance of off-highway equipment. The innermost layer of the bearings consists of a braided Nomex/Teflon tubular liner which is applied to a precision mandrel during fabrication and saturated with an epoxy resin. A low helix angle layer of epoxy-coated glass filaments is then applied, followed by several high helix angle layers. The assembly is then cured, removed from the mandrel, and the bearings finished to size. This method of construction produces a high quality bearing, and its simplicity allows bearings to be manufactured and marketed at a price level economically attractive. After an initial break-in period during which a transfer film is established on the mating surface, the wear rate of the bearing stabilizes and remains relatively constant for the life of the bearing. The wear behavior can be expressed in the following equation:  $W = 0.0001 \cdot K \cdot P \cdot V \cdot T$ , where  $W$  = radial wear in inches,  $K$  = wear factor,  $P$  = load in psi,  $V$  = sliding velocity in feet per minute, and  $T$  = time in minutes. Loading has several important effects on composite bearings. Normal application of load will cause a simple elastic deflection of the bearing along with some permanent set. CJ composite bearings can easily withstand 25,000 psi static load and 15,000 psi dynamic load with a great deal of reliability. Test results from the laboratory and the field have shown that the optimum performance can be attained by specifying a length to inside diameter ratios (L/D) ranging from 0.5 to 2.0. Results of testings show that CJ composite bearings can be used under conditions of severe dynamic loading, although performance is reduced. With regard to the coefficient of friction, the smallest bearing capable of sustaining the load should be used if the lowest coefficient of friction is desired. Bearings are capable of giving their best performance under peak operating conditions during which temperatures and loads may be higher. The Nomex/Teflon fabric wear surface of the CJ bearing is a self-contained boundary lubrication system; however, the addition of conventional lubricants often improves the overall performance of the bearing. The operating temperature range for CJ bearings is -300° F to 0.315° F. Since the CJ bearing works best in oscillation, any place there is a hydraulic cylinder or pivot is a potential application. Specific applications include



use in motor graders, front end loaders, pay loaders, back hoes, and plow transport wheels.

by Richard J. Matt; Richard T. Thompson  
Textron, Inc., Fafnir Bearing Div.  
Rept. No. SAE-760666; 1976; 12p 4refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
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HS-021 022

## MEASURING NOISE--THE STATE-OF-THE-ART

New equipment and new measurement practices for use in determining noise levels and which can assist in the direction of programs to develop quieter vehicles are reviewed. Operator environments in off-highway vehicles are complex in that the noise level continually changes during the workday. Such environments fall under the mixed noise exposure section of the Occupational Safety and Health Administration (OSHA) code for protecting workers against permanent hearing loss caused by excessive noise exposure. A technique to determine how the percent of maximum exposure can be computed if the discrete noise levels and their total accumulated time are known is described as well as a technique to determine mixed exposure. The modification of a conventional OSHA dosimeter by inserting an amplifier between the microphone and the input preamplifier allows extended range measurements to be made. With the threshold set to 86 dBA, the actual measuring range is 70 to 110 dBA which is sufficient to span the operator exposure range of most off-highway vehicles. A simple table is available for converting extended range dosimeter readings to equivalent steady OSHA level. The evaluation of pass-by noise is made much easier and faster by systems which display data in a 3-D model of dBA, frequency, and vehicle position. Equipment and procedures for analyzing whole body vibration in the field by a weighted broadband method and in the laboratory by a one-third octave method are also described.

by Anthony J. Schneider  
B and K Instruments, Inc.  
Rept. No. SAE-760672; 1976; 8p 3refs  
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HS-021 023

## ASSESSMENT OF OCCUPATIONAL NOISE EXPOSURE AND ASSOCIATED HEARING DAMAGE RISK FOR AGRICULTURAL EMPLOYEES

Background information, noise exposure measurement and analysis procedures, and noise exposure data necessary for the assessment of occupational hearing damage risk for agricultural employees are discussed. The criteria on which the proposed Occupational Safety and Health Administration (OSHA) 85 db(A) 16-hour general industry noise regulation is based was used to predict hearing damage risk. It was determined that agricultural employee occupational hearing damage risk must be based on employee noise exposure data and not agricultural equipment sound levels. Extremely wide variations exist in daily and weekly noise exposures, as related to the crop cycle. The higher agricultural employee occupational noise exposures resulted from pulled or tractor-mounted farm implements, cab radios or tape players, and stationary

processing sources, as opposed to tractors and self-propelled implements. Self-propelled forage harvesters were an exception. Due to the wide variations in the measured daily and weekly noise exposures, lifetime occupational hearing damage risk can not be assessed from one-day or even one-week noise exposure measurements, as used in the OSHA regulation and also in the International Standards Organization (ISO) R1999. Agricultural employee occupational noise exposure must be determined on an annual basis. For the 16 highest noise-exposed agricultural employees, sufficient information was obtained to establish annual occupational noise exposures. These annual exposures are summarized in tabular form. All of the annual noise exposures were less than 1.0. In conclusion, no evidence was found that agricultural employees are exposed to noise levels/durations which exceed the criteria for annual and lifetime noise exposure on which the proposed OSHA general industry regulation is based.

by John D. Harris; Bent J. Lindgren; Roy L. Mann  
J. I. Case Co.  
Rept. No. SAE-760673; 1976; 12p 8refs  
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HS-021 024

## FEDERAL REGULATION OF NOISE IN AGRICULTURAL AND OFF-HIGHWAY EQUIPMENT

Federal regulation of noise in agricultural and off-highway equipment is discussed. The Williams-Steiger Act of 1970 is intended to protect the health of employees by limiting their exposure to noise on the job, a function of Occupational Safety and Health Administration (OSHA). The Noise Control Act of 1972 gives authority to the Administrator of the Environmental Protection Agency (EPA) to issue regulations to protect the health and welfare of the general public by controlling noise levels at the point of generation (this would apply to equipment at the point of manufacture and not exclusively at the point of use). The obvious intent is that the two acts be complementary in their effects; however, since employees are part of the general public it is predictable that there will be some overlapping in the effects and there probably will eventually be some conflict between the regulations and regulators. The EPA source control regulations are fairly straightforward and require only measurement of sound levels by a prescribed routine. The OSHA regulations are more complex. First, there is some reason to doubt that the regulations apply at all to agricultural equipment. OSHA announced very early that only certain named regulations would apply to agriculture and noise exposure control was not among those named. There is a tendency on the part of both the Department of Labor and industry to forget that the duties of the OSHA Act, to comply with the standards set by the Secretary of Labor and to provide employment and a place of employment which are free from recognized hazard, are independent and that while complying with one should imply compliance with both it is not necessarily so either in fact or in law. Since the operators of off-road but nonagricultural equipment are regularly exposed for an eight-hour day and forty-hour week, the existing OSHA standard applies directly. In relation to standards, it can be concluded without much doubt that the level of effective quiet is in the range of 78 to 81 dBA, and the level of no effect which can be inferred from existing studies of the hearing loss

produced by habitual exposure to broad-band continuous noise in the range of 78 to 80 dBA.

by Floyd A. Van Atta  
Quinnipiac College  
Rept. No. SAE-760674; 1976; 6p 4refs  
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Availability: SAE

HS-021 025

## HOSE CONSTRUCTIONS

Various types of hose constructions and the materials used to fulfill the many different requirements found in automotive, industrial, mining, and construction equipment applications are described. The following three basic elements of a hose construction are discussed separately: hose inner tube, hose reinforcement, and hose cover. The function of the inner tube is to contain the fluid without changing its own characteristics or the characteristics of the fluid being conducted. The following requirements which might be considered when selecting the proper material for an application are discussed: flexibility, temperature, smoothness, compatibility, porosity, wearability, cleanliness, dimensional control, oxidation resistance, color coding, and conductivity. The following basic materials which may be mixed and reinforced with a variety of other products to produce an infinite amount of variations and used for inner tubes are described: Buna N, Neoprene, Buna S (SBR), polyvinyl chloride (PVC), ethylene propylene (EPR, EPT, EPDM), butyl, Teflon (tetrafluoroethylene or TFE), fluorinated ethylene propylene (FEP), AQP nylons (also called polyamides), silicone (polysiloxane polymer), Hytrel, Hypalon, Adiprene (urethane rubber), and the thermoset elastomers. The reinforcement (carcass) of a hose consists of strands of fibers and/or wires wound or braided around the inner tube in one or more layers in order to achieve the strength necessary to contain the pressurized fluid, or in some cases, to prevent the inner tube from collapsing under vacuum conditions. Insulating layers of thin rubber sheeting are wound around the hose to separate the various layers (plies) of reinforcement material. The following aspects of the hose reinforcement are discussed: materials, industry nomenclature, construction (e.g. braiding), lengthening-shortening effect, pressure ratings, working pressure, burst pressure, and impulse capabilities. The third basic element of the hose, the hose cover, is the outermost part of the hose. Its only purpose is to protect the carcass from weather, abrasion, chemical attack and other elements. Some materials used for hose covers (Neoprene, AQP, cotton, polyester, polyurethane rubber, nylon, Hytrel) are discussed.

by Joseph F. Briggs  
Acroquip Corp., Industrial Div.  
Rept. No. SAE-760683; 1976; 10p  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
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HS-021 026

## TESTING AND DESIGN APPLICATION PROCEDURES FOR HYDRAULIC HOSE ASSEMBLIES

The expanding use of hydraulic components in off-highway machines has increased the need to be able to properly select

components to insure adequate service life when used as a part of a complete machine. A design engineer can match expected component service loads with the capability of hydraulic hose assemblies as determined by durability-type tests in the laboratory. Existing SAE impulse-type tests can be used to generate "pressure-life curves." The selection of a hydraulic hose based on "pressure-life" curves and the expected service history are illustrated.

by H. D. Berns  
Deere and Co., Moline, Ill.  
Rept. No. SAE-760684; 1976; 11p 11refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
Availability: SAE

HS-021 027

## DESIGN AND TEST OF A 6000 PSI HYDRAULIC TUBE FITTING DEVELOPED TO MEET THE HIGH PRESSURE TREND IN OFF-HIGHWAY EQUIPMENT

A 6,000 psi hydraulic tube fitting was designed and tested to meet the trend toward high pressure in off-highway equipment. The experimental direction was to derive a set of requirements describing the ideal high pressure fitting and then implementing a design which would meet these criteria as closely as possible. The result is a fitting that meets the following criteria: a total mechanical assembly, a bite-type fitting, light in weight in relation to its pressure rating, assembly tools and costs which are not prohibitive, and virtually no limitation by physical size as to application in mobile equipment. The importance of testing during development stages of these high pressure components is emphasized using a specific design as an example. A set of nine qualifying tests (torque, holding power, remake capability, vibration, accelerated or extreme vibration, impulse, vacuum leakage, thermal shock, tests to dynamically develop the flow coefficients and derive numerical data for each fitting style) is reviewed. The test data obtained should be sufficient to permit setting up of a fitting improvement program. It should also provide some insight into the design parameters for the 10,000 psi fitting when the industry inevitably requires it. A second test program involving a four-way analysis of variance is planned to determine if any trends are discovered. Among other things, some idea of just how far this concept can be carried will be estimated. Performance changes as parameters vary will provide this information. Plans call for three fitting shapes, seven basic tests, and six sizes with data points from five samples in each parametric square. This yields a total of 630 data points which should be sufficient to achieve a good computer analysis of trends.

by L. B. O'Sickey  
Parker Hannifin Corp.  
Rept. No. SAE-760685; 1976; 12p  
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Availability: SAE

HS-021 028

# **VARIABLE DISPLACEMENT PUMP AND CONTROLS--APPLIED TO VARIABLE SPEED- VARIABLE TORQUE DRIVE SYSTEMS**

A design analysis is described that leads to optimizing the power efficiency of a hydraulic system. This analysis is concerned with matching a variable displacement hydraulic pump and its control mechanisms to its power source to derive maximum utilization of hydraulic energy in both open and closed loop control systems. The analysis is concerned with variable speed, variable torque drives typically found in material handling, and light industrial applications. This design analysis is well suited for those applications where horsepower conservation, increased machine productivity, and desired improvements in a control of hydraulic functions are desirable objectives.

by L. M. Claar  
Parker Hannifin Corp., Mobile Hydraulic Div.  
Rept. No. SAE-760686; 1976; 12p  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
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HS-021 030

# **TESTING ROPS [ROLL-OVER PROTECTIVE STRUCTURES] AND FOPS [FALLING OBJECT PROTECTIVE STRUCTURES] FOR SAFETY COMPLIANCE**

General guidelines are presented for following the SAE test procedures for SAE Roll-Over Protective Structures (ROPS) Code J1040a and SAE Falling Object Protective Structures (FOPS) Code J231 which concern safety compliance of off-highway vehicles. ROPS test procedures can be grouped into pre-test, in-test, and post-test phases. The following items should be considered during the pre-test phase: attach the vehicle frame to the fixture such that the attaching members experience minimal deflection; use either a direct or indirect method to apply the side load; have uniform ROPS deflection under side load to more closely achieve simulation of an actual rollover (achieved by proper location of the load distributor and load application point); choose load-measuring devices and deflection-measuring devices plus their respective read-out instruments so that the sum of their inaccuracies does not exceed 5%; have photographs of the test setups; and attach strain gauges at appropriate locations prior to the test if strain information is desired. During the ROPS test, side load values must be recorded at each 0.5 inch (13 mm) deflection interval. Photographs of the proceedings may be beneficial during this phase. After the test is concluded, any load linkage geometry effects which significantly change the load values must be corrected for. A complete, accurate summary of the test results in the form of a report is very important. Items which deserve special attention when testing FOPS include the following: ensure that vehicle frame or portion thereof to which the FOPS is mounted is identical to the actual structure and that the vertical stiffness of the test bed is not less than that of the actual vehicle; have a method for positioning and releasing the drop object so that it falls within the prescribed target area; take slow motion movies of the drop test to study the behavior of the FOPS during impact and to document its performance; and, unless quantitative results are of value, place a DLV (deflection limiting volume) artifact in the proper position

within the FOPS to most effectively determine if the FOPS enters the DLV.

by Ronald D. Wetjen  
John Deere Dubuque Works  
Rept. No. SAE-760689; 1976; 11p 11refs  
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HS-021 031

# **AN ANALYTICAL PROCEDURE FOR THE SUPPORT OF ROPS [ROLL-OVER PROTECTIVE STRUCTURES] DESIGN**

An analytical procedure has been developed to fulfill the need for a technical support of the design of well-balanced ROPS (Roll-Over Protective Structures) for off-highway vehicles. The procedure is incorporated in a computer program referred to as SAPROPS (Structural Analysis Program for Roll-Over Protective Structures). SAPROPS performs elastic-plastic, nonlinear analyses of space frames by the direct stiffness method. The program generates the following information as output: sequence of plastic hinge development, joint displacements, member forces and moments, load-deflection data, external work done on the frame, composite plot of exaggerated deformations (depicting response characters of the frame), and permanent set after loads are removed. Examples are given to demonstrate effective applications of the program to the design of ROPS for agricultural and earth-moving vehicles. Various loading conditions besides the SAE and ASAE codes may be evaluated to further study the adequacy, design margin, and the compatibility of the ROPS with its mounting vehicle chassis. The analytical procedure yields reasonably accurate results with a consistent pattern of variation for the side and rear loadings. The three moments (Mx, My, Mz) are decisively the dominant force components and the approximate interaction formula (yield function) is quite satisfactory for this purpose. The capability of the SAPROPS to simulate strain hardening effect has not been significant in the analysis of ROPS; exclusion of the strain hardening effect from the analysis yields a slightly conservative prediction. To effectively predict a vertical crush loading, the axial force component (Px) must be included in the yield function of a plastic hinge. Bucklings also have to be considered in the analysis. It is most desirable to have the capabilities in the computer program to handle various types of commonly used beams. Work is being done to overcome some limitations of the analytical procedure.

by Rudolph E. Yeh; Yuan Huang; Edward L. Johnson  
International Harvester Co.  
Rept. No. SAE-760690; 1976; 12p 18refs  
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HS-021 032

# **ROPS [ROLL-OVER PROTECTIVE STRUCTURES] FORCE AND ENERGY ABSORPTION FROM SIMULATED OVERTURN ANALYSIS**

A two-dimensional dynamic analysis is used to simulate an overturning condition for crawler tractors. Input for the analysis includes tractor dimensions, surface conditions, force-deflection characteristics of the tractor's roll-over protective

structure (ROPS), soil properties, initial tractor position, initial tractor velocity, tractor mass, and tractor mass moment of inertia. Results of the analysis were used to study the effect of tractor mass on the force and energy absorbed by the tractor's roll-over protective structure. Regardless of how massive a tractor may become, the side force on its ROPS is limited due to the strength of the soil on which the ROPS impacts. The side deflection of the ROPS is also limited since the ROPS must not encroach on the operator. Further, the collapse load of the ROPS also establishes a maximum side deflection. That is, too much side deflection will weaken the vertical load carrying capacity of the ROPS. Since both side force and side deflection of ROPS have physical limitations, the energy must also have a limit.

by L. J. Cobb  
Caterpillar Tractor Co.  
Rept. No. SAE-760691; 1976; 8p 7refs  
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HS-021 033

### CONTROLS FOR HYDROSTATIC TRANSMISSIONS--PRESENT AND FUTURE

The term "hydrostatic transmission" (HST) has come to mean a variable displacement pump in a closed hydraulic circuit with a fluid motor. Simple displacement and pressure controls were satisfactory for hydrostatic transmissions in the past. Modern hydrostatic transmissions presently available have improved on the performance of earlier designs. The modern systems have permitted higher power-to-weight ratio, improved overall efficiency with reduced heating, and more versatile controls. Present displacement controls have extended the usefulness of hydrostatic transmissions. These have improved performance, simplified operation, reduced power requirements, and reduced hydraulic shocks that led to costly repairs. Pumps and motors for future service are already in development or under test by progressive manufacturers. Power-to-weight ratios will continue to rise. Pumps of the future must simplify the operator's job and reduce the cost of operation and maintenance of mobile equipment.

by William H. Meisel  
Abex Corp., Denison Div.  
Rept. No. SAE-760697; 1976; 18p  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
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HS-021 034

### SELECTION AND APPLICATION OF HYDROSTATIC TRANSMISSIONS TO FARM AND CONSTRUCTION EQUIPMENT

The following steps should be taken in the selection of transmission size: consider all types of transmissions and select the best value to give the customer a good product; determine the vehicle power range and duty cycle to permit the greatest latitude when sizing the motor; select a hydraulic motor to provide adequate vehicle performance, taking into consideration the gearing that is available; select adequate pump to provide flow to motor, considering the possibilities of input gearing; and after all components have been selected, go back

through all calculations checking vehicle performance, motor application speed limit, and maximum system pressure using full engine horsepower.

by Edward J. Bojas  
Eaton Corp.  
Rept. No. SAE-760698; 1976; 11p  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
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HS-021 035

### BASIC SERVICE REQUIREMENTS FOR HYDROSTATIC TRANSMISSIONS IN MOBILE INDUSTRIAL EQUIPMENT

From a service engineering standpoint two systems for hydrostatic transmissions in mobile industrial equipment are the drive system and the supporting system. The drive system consists of the following components: the driven hydrostatic pump fixed or varied output design; the center section which is mounted between the hydrostatic pump and motor and which houses the fluid transfer passages, check valves, shuttle valve; and the hydrostatic driving motor, varied or fixed output to control speed and torque. The supporting system consists of the reservoir, a filter, dual pump, controls, cooler, and valve block. A hydrostatic transmission has two major enemies, contamination (dirt and water) and heat. The hydrostatic transmission in itself is clean-running and does not manufacture dirt detrimental to reliability or increase service demand over the conventional torque converter powershift unit. Complications can arise if proper consideration is not given to the necessity, either economic or space-wise, of using the hydrostatic reservoir as the source of fluid for operation of other hydraulic equipment. Design responsibility factors essential for good serviceability include the following: adjustments, fluid levels, adding fluid, filters, fluid changes, repairability, cooling, diagnosis, and pre-set components. With regard to manufacturing responsibilities, the assembly process of the hydrostatic parts as well as the total hydrostatic in the housing and all other parts with which the hydrostatic fluid will come in contact demand the utmost in impeccable standards of cleanliness, the in-plant operation and final inspection must incorporate special plant filtration confined to three micron ratings maximum and be operated long enough to assure a clean system, and the normal production filters must be installed as the unit leaves for the shipping area. Service responsibilities for product support include the following: operator's manual, advisory or warning decals, service publications, and tool requirements. Actual service requirements are divided into the following two categories: minor service which concerns the supporting system and problems that are easily diagnosed by use of pressure, temperature gauges and the flow-measuring equipment (e.g. suction leaks); and major service which concerns the drive system and nearly always mechanical failure and which requires the removal of the hydrostatic assembly for reconditioning and total clean-up. A service diagnosis chart adaptable to any hydrostatic unit is provided.

by V. A. Nelson; J. L. Love; A. E. Nordby  
International Harvester Co., Pay Line Div.  
Rept. No. SAE-760699; 1976; 12p  
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HS-021 036

## PRODUCT LIABILITY--IT'S EFFECT ON THE MANUFACTURER-DISTRIBUTOR RELATIONSHIP

Because product liability is becoming an increasingly important factor in the manufacture and distribution of products, a discussion is presented on the concept of strict liability in tort, how it differs from a lawsuit based upon negligence, and steps that can be taken by manufacturers and distributors to reduce their exposure to product liability. The legal theory involved in a product liability case is known as "strict liability in tort" and has been justified upon the premise that the seller, by marketing his/her product for use and consumption, has undertaken and assumed a special responsibility toward any member of the consuming public who may be injured by it; that the public has the right to and does expect that reputable sellers will stand behind their goods; that the public policy demands that the burden of accidental injuries caused by products intended for consumption be placed upon those who market them, and be treated as a cost of production against which liability insurance can be obtained; and that the consumer of such products is entitled to the maximum of protection at the hands of someone, and the proper persons to afford it are those who market the products. In a personal injury case based upon negligence, the injured party must prove the following: that the defendant owed him/her the duty to exercise reasonable care; that he/she breached the duty by failing to exercise the proper standard of care; and that the defendant's breach was the proximate cause of the injured party's damages. By contrast, in a product liability suit, the injured party need not show that the defendant failed to exercise reasonable care, but only the following: that the defendant was engaged in the business of selling the product; that the product was in a defective condition, unreasonably dangerous to the user; that the product reached the user without substantial change; and that the defect was the proximate cause of the injured party's damages. It is essential that the manufacturer and distributor cooperate to the fullest extent possible to minimize their exposure to product liability losses by adhering to the following steps: reducing the probability of injury, screening advertising, developing defect notification systems, investigating accidents, maintaining an aggressive defense in the litigation, and improving the safety standards involved with product liability.

by Robert D. Tomlinson  
Charles Machine Works, Inc.  
Rept. No. SAE-760702; 1976; 8p 7refs  
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HS-021 037

## SPHERICAL PLAIN BEARINGS--FRICTION, WEAR, AND SERVICE LIFE

A new calculating method has been developed which allows the designer to predict more accurately the service life of radial, spherical plain bearings. Spherical plain bearings were first used in aircraft and were primarily subjected to static loading; with the increasing popularity of these bearings in the automotive industry and in general machine design, the need arose to accurately predict the service life under dynamic conditions. It soon became apparent that the high contact pressure allowed for aircraft bearings did not yield an acceptable dynamic service life; the permissible contact pressure needed to be reduced considerably. The following other factors needed to

be considered also: equivalent load, type of loading, duration of loading, angle of oscillation, tilt angle, frequency of oscillation, surface speed, bearing material, hardness, stiffness of shaft and housing, heat dissipation, environmental conditions, lubricant, and relubrication period. The calculating methods presented herein attempt to account for as many variables as possible. The large variety and relative difficulty of obtaining exact data on some variables make it necessary to apply safety factors according to the user's judgment in cases where extraordinary operating conditions prevail. Relubricable steel-on-steel bearings and self-lubricating PTFE-on-chromium or PTFE-on-stainless steel bearings are treated separately.

by Werner M. Spitzig  
Ina Bearing Co., Inc.  
Rept. No. SAE-760707; 1976; 16p 4refs  
Presented at Off-Highway Vehicle Meeting, Milwaukee, 13-16 Sep 1976.  
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HS-021 038

## CORNERING COMPLIANCE APPLIED TO DYNAMICS OF ROLLING VEHICLES

Simplified mathematical models of the automobile are useful for analyzing the design of new vehicles and for studying the dynamics of driver/vehicle systems; for this study, the equations are linearized about straight-line motion, and an orthogonal axis system is employed. Root locus techniques are used to predict the effect of roll steer on transient behavior. Frequencies and decay rates for the transfer function polynomials are approximated by simple expressions involving cornering compliances. The results facilitate physical interpretation and include the influence of roll steer on dynamic behavior. The concept provides an easily interpreted approach to the study of automobile stability and control. In analyzing the effects of front and rear roll steer, it is convenient to separate the cornering compliances at each axle into roll-related and nonroll-related parts. The roots of the characteristic equation can be approximated accurately by simple expressions containing speed, cornering compliances, wheelbase, dynamic index, moment of inertia in roll, sprung mass, and sprung mass center of gravity distance above the roll axis. Rear roll understeer tends to decrease the rate of decay of one of the modes of motion, and this could result in a nuisance mode. A list of symbols is included.

by Frederick J. Winsor  
Chrysler Corp.  
Rept. No. SAE-760711; 1976; 10p 8refs  
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 039

## THE CORNERING COMPLIANCE CONCEPT FOR DESCRIPTION OF VEHICLE DIRECTIONAL CONTROL PROPERTIES

A concept for combining most vehicle design parameters into computed coefficients which are easily related to directional response characteristics is proposed using the terms front and rear cornering compliance. Understeer influences increase front cornering compliance and decrease rear cornering compliance. Two numbers are available to identify vehicle suspen-

sion qualities as opposed to one number for understeer or oversteer, making the cornering compliance technique for vehicle description a much better discriminator of vehicle handling qualities than the total understeer value by itself. The great advantage of the cornering concept is that it gives some quantitative information about vehicle transient response characteristics. Yaw response analysis of a simple vehicle model can be conducted using front cornering compliance defined as the front weight divided by cornering stiffness. As long as the cornering compliances are held constant, center of gravity can be moved with little or no effect on yaw velocity response. The shortest response times are achieved with low rear cornering compliance combined with somewhat higher front cornering compliance. Lateral acceleration response can be expressed using the same equations developed for the simple nonrolling vehicle model. Response analysis using the cornering compliance concept is based on the idea that handling response characteristics of a vehicle relate directly to its cornering compliances. Transient responses are useful in vehicle design because they illustrate the cause-effect relationship between design parameters and responses. Short times to peak response and short lateral acceleration response times should be achieved with high understeer and low total cornering compliance. Yaw velocity, response time and lateral acceleration time to peak response are highly dependent on cornering compliance, with rear cornering compliance being most effective in changing response times. Short wheelbase vehicles tend to have shorter response times. The cornering compliance concept is limited by the fact that it does not include roll dynamics. Appendices include an analysis of common tests in terms of cornering compliances, and directional control equations for a simple nonrolling vehicle model.

by R. T. Bundorf; R. I. Leffert  
General Motors Corp., Engineering Staff; General Motors Corp., Proving Ground  
Rept. No. SAE-760713; 1976; 16p 7refs  
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 040

## JOINING DISSIMILAR METALS WITH TRANSITION MATERIALS

A new concept is introduced for joining dissimilar metals, which involves use of transition materials. This method allows the joint to occur at the bond interface of the clad transition material, thus eliminating dissimilar metal welds and crevices. Methods for joining dissimilar metals in assembly include soldering, brazing, welding, bolting, riveting, and various mechanical fastening techniques. The transition material concept uses a transition material connector, composed of metal B clad to metal A, placed between the two tubings, thus converting joints to similar metal joints which can be joined with conventional techniques. Using the steel-aluminum system as an example, the joining problems associated with the formation of brittle intermetallics during welding can be avoided. The joint is accomplished through the use of a steel clad aluminum transition material such that steel to steel and aluminum to aluminum welds are formed. Since dissimilar metal crevices are avoided with this technique, galvanic corrosion is minimized. This method of joining is applicable to a wide range of dissimilar combinations. Applications on automobiles include areas where weight reduction, strength, and corrosion

resistance are required and involve the use of inserts, clips, and fasteners.

by Robert Baboian; Gardner Haynes  
Texas Instruments, Inc.  
Rept. No. SAE-760714; 1976; 16p 5refs  
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 041

## A FAMILY OF THERMOMECHANICALLY TREATED HIGH STRENGTH SHEET STEELS

A family of thermomechanically treated (TMT) low carbon steels, with strengths of 400 to 600 MPa, is proposed as an alternative to the high strength low alloy (HSLA) steels being used to reduce the thickness, and thus weight, of selected automotive stampings. The microstructure consists of randomly dispersed martensite in a strain-aged ferrite matrix. Prior to stamping, the steels are of intermediate strength and microstructurally stable. After stamping, they age rapidly at both ambient and elevated temperatures to attain their final strength. Press trials are made with a bumper bracket, truck bumpers, and a bumper reinforcement. Press formability, fatigue resistance, low temperature impact, and corrosion resistance are at least comparable to HSLA steels. The treatment is equally effective in strengthening both hot-rolled and cold-rolled low carbon steels.

by Donald J. Bailey  
General Motors Corp., Res. Labs.  
Rept. No. SAE-760715; 1976; 11p 5refs  
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 042

## RESIDUAL STRESS AND FATIGUE STRENGTH OF CARBURIZED AND QUENCHED STEEL

The fatigue limits of carburized (case depth 0.2 mm through 0.8 mm) and quenched SCr22 (similar to SAE 5120) steel specimens and their relationship to variations of residual stress distributions for 0.3 mm, 0.6 mm, and 0.8 mm case depth SCr22 specimens were determined through application of three levels of repeated stress; those equal to, higher than or less than the fatigue limit. Results indicate that if the compressive residual stress in the outer layer of the specimen is sufficiently reserved during repeated stress, residual stress contributes to a higher fatigue limit, although its distribution changes. Residual stress is shown to vary with repeated stress. As the strengths of carburized and uncarburized areas differ, the generation of residual stress under repeated stress differs. Due to the conditions of the distribution of residual stress of specimens after quenching, there are some areas where the fatigue process progresses predominantly with the residual stress acting as mean stress. As a result, the distribution of residual stress varies gradually, as does the repeated stress. The value of compressive residual stress in the other layer of specimens after quenching is important as a contribution of residual stress to the fatigue limit. But the fatigue limit is raised when the residual stress, changed by application of repeated stress, shows a distribution fit to maintain the residual stress stably in the outer layer and inner area. When case depth is thin, the

compressive residual stress in the outer layer is reduced by applied repeated stress, but in the case of stress distributions that are initially cup-shaped, compressive residual stress is again generated in the outer layer. When the case depth is deep, even if the distribution is initially not cup-shaped, compressive residual stress is not reduced by repeated stress. When it is cup-shaped, more stable distribution of residual stress is obtained. In each case, when the distribution of residual stress in the outer layer before repeated stress oscillates initially as it goes to the outer surface, the contribution to the fatigue limit is large.

by Moritaro Motoyama  
Nissan Motor Co., Ltd.  
Rept. No. SAE-760716; 1976; 8p 2refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 043

## DESIGNING AN IN-LINE FIVE

In adding one cylinder to the existing four-cylinder unit, the problem was to achieve acceptable dynamic balance with an inherently unbalanced configuration. Adopting an even firing interval of 144° of crankshaft rotation results in a crank pattern of 5 x 72°, which precludes arranging individual crank throws to cancel the primary and secondary couples. Primary and secondary inertia forces, however, are reduced to zero with this configuration. Only minimal excitation was attributable to the secondary couple, and hence primary-couple minimization was the principal design goal in choosing a crank pattern. One result was the firing order sequence 1-2-4-5-3. To prevent an imbalance being transmitted to the rest of the vehicle from the vibration in the engine, one of the vectors of the primary couple may be varied to generate either a vibration about the horizontal axis, a diminished, compound "rocking" motion, or a vertical vibration. This selectable mode of vibration gave designers an option in locating engine mounts and other engine/vehicle connections with particular vibrational characteristics in mind. Relatively small amounts of imbalance in the torsional-damper hub and flywheel were sufficient to produce the necessary pair of counteracting forces. With the front-wheel-drive layout, the entire powertrain, consisting of engine, clutch, differential, and transmission, has a substantially greater moment of inertia than that of the engine alone; thus the complete unit, if made sufficiently rigid, is subject to less vibrational response than would be the engine in isolation. Among design features carried over from the Audi's 4-cylinder unit are cylinder spacing, bore, crankcase and head heights, head bolt patterns, main bearing design, and location of valves, spark plugs, and fuel injectors. New features incorporated into the 5-cylinder design include engine/transmission reinforcement, lower-end modifications, exhaust manifold in a dual configuration, cylinders 1, 2, and 5 feeding one pipe and 3 and 4 the other, a combustion chamber design with most of the chamber volume lying in the cylinder head, concentrated around the spark plug, and separate auxiliary drives for the oil pump, distributor, and fuel pump. A Bosch K-Jetronic fuel injection system is used, with the injectors supplying a continuous spray of fuel to the intake valve ports. U.S. versions operate on a lean mixture, with no air pump, but with a catalytic converter on California cars. The U.S. version develops 103 hp at 5,300 rpm, with maximum torque of 112.3 ft-lb at 4,000 rpm. Fuel economy figures, measured on the

CVS 75 cycle, are in the 17-19 mpg range for the city and 24-27 mpg for the highway.

Publ: Automotive Engineering v85 n4 p26-9 (Apr 1977)  
1977  
Based on SAE Paper 770112 by Franz Hauk and Werner Dommes.  
Availability: See publication

HS-021 044

## DRUGS AND DRIVING

A critical review of research literature on the effects of drug use on traffic accidents and fatalities includes illicit, prescription and over-the-counter drugs, some alcohol studies with strong emphasis on studies of alcohol in combination with other drugs. Critical analysis concentrates on the type of performance functions tested or measured and methodological approaches used. Detection techniques are also included. The review was conducted by a panel of experts on the behavioral effects of drug usage. Each expert prepared an individual summary review and critique of a portion of the literature. The reviews are organized by drug clusters, selected according to the World Health Organization's designation and grouping. References for the studies selected by the panelists for review are included at the end of each individual review. Studies are made of anaesthetics and foreign tranquilizers, general tranquilizers, opiates and minor tranquilizers, sedatives, stimulants, marihuana, general hallucinogens and other drugs. Recommendations were developed in three major categories. In drug categories, the first level of priority for further study is alcohol: to determine the frequency and quantity of use by people engaged in complex performance, assess the frequency of use by these people as against that of marihuana and cigarettes, and to determine how much the impairment caused varies with the frequency and quantity of use. Second level of priority for study cannabis and diazepam (Valium) and their derivatives; third level is sedatives and hypnotics. Methodological topics suggested for future study include epidemiological studies, laboratory studies, with development of a battery of psychomotor tests to detect the presence of certain side effects of drug use, and drug assays, with tests to measure impairment as a function of dose. Studies of unnecessary usage of tranquilizing drugs should be undertaken; law enforcement officials should focus more on erratic driving behavior itself than on the causes of it, and drivers should be arrested for "driving erratically" rather than for "under the influence," since present detection methods for the presence of drugs in the body are not sufficiently developed. Expanded labeling and education programs should be promoted, defining levels of risk associated with the drug use. A supplemental bibliography on drugs and driving and a list of monographs in the series are included.

by Robert E. Willette, ed.  
National Inst. on Drug Abuse, Div. of Res.  
Contract NIDA-RM-271-75-1016  
1977; 151p 141refs  
Papers derived from panel conference held 20 Aug 1976 at Rockville, Md.  
Availability: GPO Stock No. 017-024-00576-2

## EVALUATING FUEL-SYSTEM CRASHWORTHINESS

General Motors (GM) Proving Ground's Safety Research and Development Laboratory has developed a rollover fixture, consisting of a rotating carriage suspended between two commercial truck lifts, to test vehicles for conformance to FMVSS 301, Fuel System Integrity, requiring that after 30 mph crashes, vehicles must retain essentially complete integrity of their fuel systems while undergoing simulated rollovers. Two electric motors drive the carriage at a fixed rate of two minutes for each 90° rotation. At each end of the rollover carriage there are two 18.5/8-in. diameter pistons which are mechanically synchronized by a rack and pinion height equalizer. Total lift capacity of the system is 36,000 lb. The lift mechanism is designed to withstand off-center and torsional loads encountered during vehicle rotation. Hydraulic power comes from dual 7.5 hp motors driving vane pumps of 40 gpm rating. To synchronize the lifts, a flow divider is incorporated into the hydraulic control unit; it functions as three identical hydraulic motor/pumps having a common armature. This hydraulic flow system is shown schematically. The rotation system has dual drive, selected to minimize equipment interference with the vehicle understructure. To protect the rotating equipment, a torque-limiting device is incorporated between each motor and its first-stage reduction unit; a pneumatic brake is fitted as an added safety device. The two rotating drives are synchronized by monitoring angular displacement with shaft encoders. The rotating structure consists of two longitudinal steel rails attached to the pivot arms by means of gimbals at each corner. The complete test cycle at GM takes 21 minutes, with three 5-minutes dwells at each of the four orientations. The actual rollover cycle is controlled from a portable console, with override switches giving the operator control of all functions except roll synchronization. This equipment has been in operation since Nov 1974; last year some 150 vehicles were subjected to testing.

General Motors Proving Ground, Safety Res. and Devel.

Publ: Automotive Engineering v85 n4 p30-3 (Apr 1977)

Based on SAE Paper 770173 by Charles R. Meier and Robert D. Ballmer.

Availability: See publication

HS-021 046

## MICROPROCESSORS AND THE AUTOMOBILE

Microprocessor control offers a resolution of the inherently contradictory problems of fuel economy, emission control, and driveability. The evident elements of a control system include: sensors, whose contribution may be a pure analog signal, a sequence of timed pulses, output already in digital form, or a two-state variable. The general organization of the microprocessor is shown in a diagram. Advantages over the analog counterpart are that digital components lend themselves to miniaturization, and large scale integration has brought computation costs downward with each generation of chip design; power dissipation is low, and they do not exhibit the operational drift associated with their analog counterparts; and the digital approach offers the flexibility of software modification; a microprocessor need not be dedicated to only one control strategy. Either hardware, the "hard-wired" logic paths, or software, a stored set of instructions, can be used to perform many functions. Among the large-scale integrated circuits dedicated to automotive applications, several options are cur-

rently under discussion. In Subsystem Dedication, a central ROM is shared by several LSI devices, each of the latter dedicated to a particular controlling function. Programmable Logic Arrays offer essentially hard-wired dedication without a complete loss of microprocessor flexibility, containing an array of logic gates interconnected to provide a variety of possible paths. Limitations of microprocessor control exist, principally in the areas of resolution, accuracy, and response time. The great challenge in the trend toward more system integration of electronic functions lies in developing reliable, cost-effective sensors and actuators.

Publ: Automotive Engineering v85 n4 p34-41 (Apr 1977)

Based on SAE Paper 770001 by Kurt Binder, Uwe Kiencke, and Martin Zechner; SAE-770002, by M. David Freedman; SAE-77004, by E. Floyd Kvamm and Jerry R. Crowley; SAE-770008, by A. O. Toelle; and SAE-770160, by Richard A. Blanchard. (Papers available in SAE-SP-417.)

Availability: See publication

HS-021 047

## FINITE ELEMENT STRESS ANALYSIS

To solve practical engineering problems using general-purpose finite element computer programs, stress analysts must be concerned with selecting finite element types which are appropriate and cost effective; obtaining a cost effective finite element model with good modeling techniques; interpreting computed displacements, stresses, and strains and assessing their accuracy; and developing necessary design changes and re-analyzing to determine whether improvements have been achieved. Stress analysis objectives should be established prior to the selection of a modeling strategy. If prediction of overall behavior and engineering stress estimates is the primary objective, a reasonably coarse mesh of finite elements can be utilized; if the objective is to predict highly localized stresses, such as at stress concentration points, a relatively fine mesh of finite elements must be provided in the high stress-gradient areas. An example problem is given in which a square plate subjected to a concentrated load at its center was analyzed for simply-supported and clamped-edge conditions by modeling a corner quarter of the specimen with finite element meshes starting at 1 x 1 and going to 10 x 10 in steps of 1. Finite element stress analysis has proven effective both in the pressure-load case of the behavior of a diesel engine aluminum piston under operating loads (including effects of the wrist pin, connecting rod, gas leakage, and temperature dependence of the material properties) and for the modeling of a backing plate for an automotive brake to predict high stresses and failure zones (incorporating the effects of anchor pins and rigid cylinders).

Publ: Automotive Engineering v85 n4 p44-8 (Apr 1977)

Based on SAE Paper 770605, by E. Citiptoglu, V. T. Nicolas, and S. K. Tolani.

Availability: See publication

HS-021 048

## EVs [ELECTRIC VEHICLES] WILL ROLL

Passage of Public Law 94-413 late last year commits the Energy Research and Development Administration (ERDA) to the purchase of some 7,500 electric-powered or electric-hybrid vehicles (EV's) in the 1980's; a number of major manufac-



turers are developing EV hardware for competitive bidding. The U.S. Postal Service has had British-made electric vans in operation in Cupertino, California, since 1969 with good results. Fuel and maintenance costs were half as much as for gasoline vehicles, and there has been no deterioration. The Japanese government is supporting the second stage of an intensive program to develop EV's particularly for urban use. Their engineers are working on a hybrid EV somewhat different from the usual hybrid propulsion system, which typically consists of a small, onboard IC engine for battery charging and/or supplementary propulsion. The Japanese design involves two types of batteries; lead-acid is used for starting and acceleration, then a metal-air battery (high energy, low power) takes over during steady-state, continuous running. The system is being tested in a 1-ton cab-over truck in which the relatively small lead-acid battery pack is mounted behind the driver in the cab, with the big zinc-air battery slung under the frame at about vehicle midpoint. The vehicle's 37-hp, rear-mounted, dc shunt motor is fitted with a heat-pipe-cooled rotor. A high-current, reverse-conduction thyristor and common chopper control the propulsion system in running and regenerative-braking modes. This system is said to provide optimum control of the hybrid-battery arrangement during cruising and permit a wide range of speed and torque through automatic field weakening. Fiat's two-passenger "city car" is front-wheel driven by a 13.5-hp separately excited dc motor. Nickel-zinc batteries provide a range of 70 miles at a constant speed of 31 mph. Maximum speed is 47 mph. Motor control is achieved with a double transistor chopper operating on armature and field currents, transistor control of the armature being superior to thyristor control, according to Fiat. The lead-acid battery is conceded to be most efficient in terms of cost, performance, and reliability. ERDA is sponsoring development of both a near-term "improved state-of-the-art" and a longer term "advanced" lead-acid EV battery; performance goals are presented in a table.

by Clare F. Wise

Publ: Machine Design v49 n17 p26-8, 30 (21 Jul 1977)

1977

Availability: See publication

HS-021 049

## PHYSICAL MEASUREMENTS OF U.S. INFANTS, CHILDREN, AND TEENAGERS

A two-year anthropometric measurement study was made of infants, children, and teenagers ethnically, socioeconomically, and geographically representative of the U.S. population. The data are needed for use in designing safer consumer products. Two teams of anthropometrists obtained 87 different body measurements of 4,127 subjects ranging in age from two weeks to 18 years, using portable automated data acquisition systems in 104 locations in eight regions of the country. The subjects, measured in schools, nurseries, day care centers, and clinics, were selected in accord with a random sampling plan based upon 74 primary sampling units maintained by the Survey Research Center of the U-M Institute for Social Research. Techniques and results are described for four measurements: stature, weight, vertical grip reach, and a functional hand measurement, distance from thumb crotch to tip of middle finger. The final report of the study presents, for each of 16 age group, the sample size, mean, standard deviation, 5th, 50th,

and 95th percentiles for each of the 87 measurements, for males, females, and combined sexes.

by R. G. Synder; L. W. Schneider; C. L. Owings; H. M. Reynolds; A. M. Schork; D. H. Golomb

Contract CPSC-C-75-0068

Publ: HSRI Research Review v7 n6 p1-19 (May-Jun 1977)

1977; 24refs

Availability: See publication

HS-021 050

## AN ANALYSIS OF INDUSTRY RESPONSES TO FEDERAL REGULATIONS IN SAFETY REQUIREMENTS FOR NEW AUTOMOBILES. FINAL REPORT

Reaction of the motor vehicle industry to regulations imposed by the National Traffic and Motor Vehicle Safety Act of 1969 is described in a series of tables. A cursory examination of those standards considered by the industry to be of questionable or nuisance value indicates they may have been promulgated hastily and without significant R and D, and were of recent development. Industry had not been involved in defining the problem. Three specific cases were chosen for further study. MVSS 203, Steering Wheel/Impact, was part of the original group of standards; it is considered to be a good standard by industry; was preceded by lengthy industry R and D; and promulgation occurred fairly quickly. MVSS 212, Windshield Mounting, was part of the second generation of standards; the development occurred exclusively within NHTSA; promulgation occurred at moderate speed; and industry considers it an effective standard. MVSS 215, Exterior Protection, has been a recent promulgation; has been a very controversial standard; involves the Cost Savings Act "economic benefit" clauses; is considered of questionable value by the automobile industry, and litigation was contemplated; and it has had significant research and development both by government and industry. Study indicates that societal attitudes and economic conditions are an important factor in the industry's responses to proposed rules and that industry continues to feel that government does not understand the time relationships between automobile design and the industry's pre-production cycle, planning cycle. A major industry concern was the problems and increased costs which would result from not allowing sufficient time to permit incorporation of the necessary design changes into the normal production process. Further concern was over lack of precision in defining standard requirements and test procedures, believed to be the result of insufficient research and development prior to rulemaking. Lead time requirements should be more precisely understood; current benefit/cost relationships should be examined with the use of actual data (eight standards of "questionable value" are suggested for evaluation); assessment should be made between company size and the cost of implementing a standard; research by government and industry should be coordinated; and a long-term implementation plan should be developed. Appended are a number of detailed comments by the Ford Motor Co. on proposed safety standards, and Motor Vehicle Safety Standards 203, 212, and 215.

by Howard M. Bunch; Michael Kubacki

University of Michigan, Hwy. Safety Res. Inst., Ann Arbor, Mich.

Contract TS-13084

Rept. No. UM-HSRI-77-14; 1977; 104p 19refs

Rept. for 10 Nov 1976-12 Apr 1977.

Availability: See publication

HS-021 051

## RESULTS OF THE 1973 NATIONAL SURVEY OF MOTOR VEHICLE FIRES

A field survey and analysis of motor vehicle fires and "fire-related incidents" was conducted with the twofold purpose of collecting data pertaining to the nature of such incidents and estimating the cost to public fire departments of combating them. Standardized field incident reporting forms were distributed to 51 fire departments in the four major geographic regions of the U.S., serving a population greater than seven million. The data provided suggest that fire departments are not overresponding to motor vehicle incidents; their provision of an average of less than one-third more equipment than that possibly needed suggests that the average response is relatively conservative. Comparisons are made between the frequencies of fire origin for noncollision and collision-related passenger car fires, with areas of fire origin designated. In the passenger compartment, fires generally do not result from collisions, but from smoking materials and defects in electrical wiring. In noncollision fires in the engine area, the majority are caused by carburetor malfunctions. The frequency of collision-related fuel tank area fires is 11 times greater than the collision level of 3%. Collision-related passenger compartment fires are about one-ninth as frequent as noncollision fires in this area, and the proportions of collision and noncollision engine area fires are nearly comparable. The survey of fire incidents by age of vehicle indicates that the probability of fire increases markedly with the age of the vehicle. A table presents frequency distribution of fires and collision-ruptured fuel tanks by make of vehicle. Due to a poorly located track-bar bolt, pre-1966 Ford sedans seemed unusually susceptible to fuel tank ruptures caused by rear-end collisions; Ford has since modified the design. The frequency of fire spills among the surveyed collisions was directly related to the number of vehicles involved. Fires were most frequent among one-car collisions, however. Recently NHTSA has adopted a number of collision-related fuel system safety requirements. One requirement limits the tolerable fuel system leakage from a static rollover following a 30 mph frontal crash; others include a 30 mph rear moving barrier crash, 30 mph angular frontal barrier crash, 20 mph lateral moving barrier crash, and a static rollover test following each barrier crash. Improvements in insulating and positioning electrical wiring are recommended, and firewalls in the rear of passenger compartments.

by Eugene M. Trisko

Publ: Fire Journal v69 n2 p19-27 (Mar 1975)

1975; 12 refs

Availability: See publication

HS-021 052

## A STUDY IN FIRE DEPARTMENT COST ALLOCATION

A summary is made of the results of research in the field of municipal protection finances and motor vehicle fires, and a cost allocation technique is outlined applicable to fire department operations. Two methods have been examined for possible application to the measurement of motor vehicle fire costs: the incremental approach, assuming that fire department fixed costs would remain unchanged in both the short and long run, given an absolute reduction in the incidence of motor vehicle fires and related incidents, and the incremental cost approach which discounts entirely the multiple societal benefits generated by fire department operations. The validity of a

fully-distributed cost analysis was explored. Its principal advantage lies in its apportionment of both fixed and variable costs across the spectrum of fire department services, assigning to each type of response a portion of total costs. These costs were divided into five categories: fire suppression, fire prevention, training, administration, and other. None of these criteria is appropriate for the allocation of fire prevention and training costs, since despite the high frequency of motor vehicle fires, most departments have no program designed to alert the public to fire dangers in vehicles, and only a small portion of classroom training hours are devoted to motor vehicle fires. Operational expenditures of each type of volunteer department may be allocated according to the relative frequency of response to motor vehicle fire incidents; this applies as well to running costs and equipment maintenance. The allocation techniques applied here on a macroeconomic scale may also be used to estimate the allocable cost of motor vehicle fires on a municipal basis, and are susceptible to further development and modification so that the cost of any fire department emergency activity may be estimated on a local or national basis.

by Eugene M. Trisko; Elwood W. Shomo

Publ: Governmental Finance p24-8, 33-6 (Nov 1974)

1974; 9p 5 refs

Availability: See publication

HS-021 053

## HIGHWAY ENGINEERING AND TRAFFIC SAFETY

The late Thomas H. MacDonald, long-time Commissioner of the Federal Bureau of Public Roads, stated that highway capacity adjusted to traffic volume is a major factor in safe highway design, that true economy is served only if this test is met, that safety thus becomes a direct measure of efficient as well as economical design, and that safe highway design is economical when all costs of highway transportation including accidents are considered. In Jul 1966 the U.S. Congress stated that to get safer highways for construction dollars, fewer, safer miles must be built. This Congressional message has been taken to heart by highway engineers especially in the development and construction of controlled-access highways, of which the Interstate Highway System represents the finest example. The lower death and accident rates on the System and other freeways are clearly the result of engineering improvements, the control of access undoubtedly the major factor. Tables and graphs provide statistical data on the lower death and accident rates (1969-1975) on the Interstate Highway System than on other types of roadways. A sharper decrease from 1973 to 1974 in the interstate death rate as compared with the noninterstate rate probably reflects the greater effect on the Interstate Highway System of the 55 mph speed limit. New impetus was given safety in highway engineering in 1967 by the publication of a report by the American Association of State Highway Officials, the publication popularly known as the "Yellow Book". This report brought about the inclusion of a number of safety features in new highway construction as well as the addition of some of the features to existing highways. Statistical data presented in tabular and graphical form suggest that the newer and improved sections of highways have significantly lower accident and fatality rates. In recent years highway engineers have emphasized the need to eliminate roadside obstacles. If a roadside hazard cannot be removed, relocated, or modified to be less lethal, it can often be shielded to protect a vehicle that might otherwise crash into it. Also pointed out are the following elements which can benefit from highway engineering measures: pedestrians,

by David M. Baldwin  
Publ: Traffic Quarterly v31 n3 p371-84 (Jul 1977)  
1977; Srefs  
Availability: See publication

HS-021 054

## IMPROVEMENT OF THE EFFECTIVENESS OF MOTORIST WARNINGS AT RAILROAD-HIGHWAY GRADE CROSSINGS. FINAL REPORT

Xenon flash lamps are suggested for highway-railroad grade crossings on the basis of a study of situations faced by the motorist approaching a railroad crossing, of flashing-light equipment currently in use, and of functional and performance specifications for grade-crossing lighting. As for intensity, 200 candela are necessary for a viewing distance of 330 ft in normal daytime conditions and 200-500 candela for nighttime viewing from 20-50 ft. The illumination pattern must be such that as the motorist approaches the signal by moving out of the brighter central part of the light beam, the resultant decrease in brightness will be compensated by the reduction in viewing distance, in a variety of possible light locations and viewing points. The combined flash rate should be at least 90 per minute or 1.5 Hz, but preferably 120 per minute or 2.0 Hz. Flash duration guidelines are that the shorter the pulse down to about 0.2 seconds, the lower the amount of energy required. As for color, a lighter shade of red (perhaps even an orange shade of red) is recommended rather than the traditionally deep red: the roundel color should pass light of 620 nm average wavelength with color chart coordinate of y00.308. The xenon flashlamp system consists of the lamp sealed in a coiled tube, energy storage power supply, and trigger circuit. The production of light pulses and system configuration are described in detail. Xenon flashlamps should have a useful life of at least several years with almost total freedom from complete failure. Their intensity of light output can be easily changed by changing the value of energy storage capacitance so that higher intensities can be used during the day and lower ones at night. The alerting effectiveness of a flashing light depends on first getting the motorist's attention (by very short, intense bursts of light giving greatest possible contrast with ambient illumination) then on correctly signaling or giving information (by positioning, alternation of flashes, color) as to the meaning of the light. Equations determining the effective intensity of flashing lights are described. Xenon flashlamps produce more than three times the effective light of tungsten-filament light of the same power consumption; with use of a 75% efficient power supply, the xenon lamps are nearly five times more effective. Experimental installations have been made in cooperation with three railroads using xenon strobes as supplements to rather than replacements of existing lights. Adaptation to conventional mounting hardware was not difficult. It may prove possible to reduce costs and power consumption through elimination of some or all incandescent lights. Severe demands now made on cantilever structures can be reduced through simplified tailoring of the light intensity to both crossing location and ambient illumination. One assembly

FRA/ORD-77/07; DOT-TSC-FRA-76-25; 1977; 31 refs.  
Rept. for Jul 1974-Jun 1976.  
Availability: NTIS

HS-021 055

## EVALUATION OF SERVICE AND METHODS DEMONSTRATION PROJECTS: PHILOSOPHY AND APPROACH. INTERIM REPORT

A descriptive summary of the philosophy and technical approach to evaluation of Service and Methods Demonstration projects, which are conducted by DOT's Transportation Systems Center (TSC), for the Urban Mass Transportation Administration, is intended as a guide for future project evaluations. TSC, employing a single, coordinated demonstration evaluation program, focuses on assessment of feasibility of techniques; transportation and socioeconomic impacts of the demonstration projects; and guidance for future applications of concepts and techniques. Evaluations are structured around three basic items: changes made to the transportation system, the impacts of those changes, and reasons for occurrence of impacts. The evaluations typically emphasize examination of short-run (two-year to three-year) impacts. Standardized evaluations are built on specified output requirements and close technical supervision; development of improved methodology; and devising strategies for cross-cutting analysis of demonstrations. The analytical framework for evaluations is based on transportation principles of supply and demand. Demonstration evaluations contain eight components: background and objectives; setting; processes of implementation and operations; and analysis of level-of-service (supply) changes. Other components include: travel behavior (demand) changes; operator impacts and productivity; non-travel impacts; and a summary.

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Rept. No. UMTA-MA-06-0049-77-5; DOT-TSC-UMTA-77-26; 1976; 21p 3refs  
Part of UMTA/TSC Project Evaluation Series, Service and Methods Demonstration Program. Rept. for Jun 1976-Oct 1977.  
Availability: NTIS

HS-021 056

## INTERNATIONAL SYMPOSIUM ON AUTOMOTIVE PROPULSION SYSTEMS (4TH). VOL. 2. SESSIONS 4 AND 6

Proceedings of two sessions of the symposium include 15 presentations on alternative automotive fuels such as methanol, methanol-indolene blends, methanol-gasoline blends, acetylene, hydrogen, and hydrides.

Energy Res. and Devel. Administration; North Atlantic Treaty Organization, Com. on the Challenges of Modern Society  
1977; 462p refs  
Collection of papers presented at the Symposium, Washington, D.C., 17-22 Apr 1977.  
Availability: Corporate author

## FLAME SPEEDS, PERFORMANCE AND EMISSIONS WITH METHANOL-INDOLENE BLENDS

Methanol, added at different ratios to indolene, has various effects on combustion, performance, and emissions in a CFR-SI engine. Flame speed is measured by two techniques: fixed ionization probes and a newly developed travelling ionization probe. The resulting turbulent flame speeds, computed laminar flame speeds, and the equivalent spherical flame speeds are analyzed to detect the turbulence decay over the cycle. The following effects were noted: increased octane number and brake specific fuel consumption, improved thermal efficiency, increased flame speed, increased BSCO and BSMC and decreased BSN<sub>ox</sub> emissions. An overall view of the test rig is included, and 20 charts and diagrams showing experimental results.

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Grant NSF-GI44218; AER74-20320A01  
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Availability: In HS-021 056

HS-021 058

## THE EFFECT OF BLENDING METHANOL WITH GASOLINE ON GEOMETRIC DISTRIBUTION

A four-cylinder, carbureted engine was fueled with Indolene (gasoline) and a blend of Indolene and 20% by volume methanol to determine the effect of the blend on geometric distribution. The engine parameters varied were: engine speed, manifold vacuum, equivalence ratio and simulated cruising speed. The results showed that while both fuels, in general, exhibited similar distribution patterns as a function of the engine parameters, the blend fueled mode of operation yielded a greater difference between the fuel-air equivalence ratios of the richest and leanest cylinders. Individual-cylinder fuel-air equivalence ratios were determined by analysis of the exhaust gas sampled from each cylinder's exhaust port. The results presented give additional confirmation of the validity of extending the methods of equivalence ratio determination for gasoline fueled engines by exhaust gas analysis to methanol blend fueled engines. Tables are appended giving measuring instrumentation and simulated cruising speed test engine conditions, and nine charts showing test results.

by R. R. Adt, Jr.; K. A. Chester; J. M. Pappas; S. Rajan; M. R. Swain; C. K. Wiesner  
University of Miami; Hawthorne Res. and Testing, Inc.  
Contract EPA-R803401-01-0; ERDA-E(40-1)-5216  
Publ: HS-021 056, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v2 1977; 27p 10refs  
Availability: In HS-021 056

HS-021 059

## RECENT PROGRESS IN AUTOMOTIVE ALCOHOL FUEL APPLICATION

Results are given from Volkswagen's Alcohol Fuel Program testing alcohol-gasoline blends, pure alcohols, and methyl and

ethyl fuels. A test fleet of 45 vehicles used a 15% methanol mixture was studied for behavior during cold start driveability in the warm-up phase, behavior during hot start driveability after the engine had reached its operation temperature. In general, no cold start or vapor lock problems were encountered during the last test year. Driveability of the warm engine was satisfactory; some driveability problems in the warm-up period need further attention. A test fleet of vehicles used straight methanol or methyl fuels for two years. Cold start problems were solvable; no vapor lock problems were encountered. Durability tests are now being conducted in Brazil using straight ethanol in three test cars equipped with ethanol fueled 1.5 liter air-cooled VW engines. Increased ignition voltage and longer ignition sparks are found to improve driveability; an addition of 5 to 10 vol.% of gasoline to ethanol improved the driveability of the test vehicles greatly. A set of figures gives the results of basic engine bench tests with alcohol; based on these findings VW Research has developed several prototype vehicles. After carburetor and ignition system adjustments as required, driveability was found to be satisfactory when the engine had warmed up. However, cold start limit of pure methanol as well as of ethanol is not satisfactory; two solutions are suggested: using an auxiliary fuel for starting (expensive) or mixing starting additives with the alcohol fuel (more practical). The value of methanol compared to that of gasoline according to price; it is recommended that if methanol is to be introduced into the fuel market, blended fuels should be the first step, since all vehicle modifications required by this are of minor significance.

by W. E. Bernhardt; A. Koenig; W. Lee; H. Menrad  
Volkswagenwerk AG, Wolfsburg, Federal Republic of Germany  
Publ: HS-021 056, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v2 1977; 29p 7refs  
Availability: In HS-021 056

HS-021 060

## ALTERNATIVE FUELS WITH REGARD TO LPG AND METHANOL

An extensive research program was carried out in which exhaust emission produced in seven European cars, running on four different gasolines (leadfree low octane, free high octane, premium and regular), liquid petro gasoline (LPG), and natural gas (NG) were compared, results showing favorable emission data for LPG and Detailed exhaust emission measurements were made on several types of Otto engines using different liquid and gaseous fuels. The results of the tests according to ECE 15 presented in a number of tables. Programs to study the use of LPG in public transport are being developed in several European cities; results so far show attractive exhaust emission figures, low noise, and acceptable fuel consumption. The experience with methanol as a fuel is substantially less extensive. Application of methanol as a 15% blend in gasoline appears to be economical in the near future (within five years), while application of pure methanol probably will not be feasible some time.

by J. van der Weide; P. Tiedema; J. A. N. van Ling  
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Publ: HS-021 056, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v2 1977; 38p 14refs  
Availability: In HS-021 056

# **VEHICLE EVALUATION OF NEAT METHANOL - COMPROMISES AMONG EXHAUST EMISSIONS, FUEL ECONOMY, AND DRIVEABILITY**

Two cars, one carbureted and the other fuel injected, were modified to burn neat methanol. Exhaust emissions, fuel economy, and driveability were measured and compared to those obtained with gasoline in the unmodified (production) cars. Since acceptable driveability and durability were obtained only with the fuel injected car, it was used to investigate the spark timing and equivalence ratio settings which would give an acceptable compromise among exhaust emissions, fuel economy, and driveability. Average equivalence ratios of 0.96 to 0.62 and spark timings from best power to 15° retarded were studied. With spark timing set for best power and the average equivalence ratio for maximum fuel economy (0.83), driveability was acceptable and CO and NOx emissions met the 1977 standards. However the unburned fuel emissions exceeded the 1977 standards for hydrocarbons, even though the car was equipped with a catalytic converter. At 0.83 average equivalence ratio, NOx emissions were reduced below the statutory standard (0.4) by retarding spark timing; however, driveability and fuel economy deteriorated. Neat methanol fueling of vehicles appears to be more successful than using methanol-gasoline blends. However, one serious problem is inability to start at temperatures below about 5° C; another problem concerns some current fuel system materials which are incompatible with methanol. Appended are a series of graphs, tables, and diagrams displaying all pertinent data.

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Propulsion Systems (4th)," Washington, D.C., 1977 v2  
1977; 81p 31refs  
Availability: In HS-021 056

HS-021 062

# **EVALUATION OF ACETYLENE AS A SPARK IGNITION ENGINE FUEL**

In spite of its known shortcomings as a fuel for spark ignition engines, acetylene has been suggested as a possible alternative to petroleum-based fuels since it can be produced from non-petroleum resources (coal, limestone, and water). Therefore, acetylene was evaluated in a single-cylinder engine to investigate performance and emission characteristics, with special emphasis on lean operation for NOx control. Testing was carried out at constant speed, constant airflow, and MBT spark timing. Equivalence ratio and compression ratio were the primary variables. The engine operated much leaner when fueled with acetylene than with gasoline. With acetylene, the engine operated at equivalence ratios as lean as 0.53 and 0.43 for compression ratios of 4 and 6, respectively. However, the operating range was very limited. Knock-induced preignition occurred either with compression ratios above 6 or with mixtures richer than 0.69 equivalence ratio. Both the indicated thermal efficiency and power output were less for acetylene fueling than for gasoline. Acetylene combustion occurred at sufficiently lean equivalence ratios to produce very low NOx and CO emissions. However, when the low NOx levels were achieved hydrocarbon control was not improved over that with gasoline. Despite the potential for NOx control with acetylene fueling, the poor anti-knock quality and the safety problems

performance  
potential performance of hydro-  
are equivalence ratio and therm.

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Contract DOD N00014-75-C-0220; N00014-67-A-0202-0046  
Publ: HS-021 056, "International Symposium on Automotive  
Propulsion Systems (4th)," Washington, D.C., 1977 v2  
1977; 37p 32refs  
Availability: In HS-021 056

HS-021 064

# **CHARACTERISTICS OF A SINGLE-CYLINDER HYDROGEN-FUELED IC-ENGINE USING VARIOUS MIXTURE FORMATION METHODS**

In the hydrogen engine, external and internal mixture formation are possible. External mixture formation, in the intake pipe by use of suitable means (induction pipe, modified carburetor, etc.) results in a loss in volumetric efficiency, because at stoichiometric conditions hydrogen occupies about 30% of the total volume of the mixture. This loss can be avoided by internal mixture formation, if hydrogen is injected into the combustion chamber after inlet valve closure. Additionally, backfiring is impossible with this kind of mixture formation. Disadvantages of the internal mixture formation are the need for a higher pressure supply of hydrogen to be able to inject it against the rising pressure in the cylinder during compression, as well as the expense for special injection valves and their appropriate control. A compromise, which takes account of

good output, no backfiring, and low pressure level (for use with metal hydride storage) is the internal mixture formation by direct injection in the early compression stroke with a pressure of 2 bar (0.2 MPa). The engine's operational parameters were set to reach minimum fuel consumption and minimum emissions. This involves combined quality/quantity-control and a compression ratio of 7:1 to avoid knocking at stoichiometric air/fuel-ratios. A table comparing different mixture formation methods, and a series of graphs, are appended.

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Availability: In HS-021 056

## HS-021 065

### RESULTS OF HYDRIDE RESEARCH AND THE CONSEQUENCES FOR THE DEVELOPMENT OF HYDRIDE VEHICLES

From the results attained with the hydride-powered vehicles and hydride development at Daimler-Benz it can be demonstrated that hydrogen storage in metal hydrides for virtually nonpolluting automotive propulsion systems has a number of system-specific advantages which, to some extent at least, make up for the relatively adverse weight proportions of the storage tank as compared to liquid hydrocarbons. Provided that suitable hydrides are chosen, the hydride tank assumes at least the following functions at the same time: fuel supply, air-conditioning, water condensation, and storage of waste heat from the engine. The hydrogen-powered vehicle equipped with an internal combustion engine and hydride storage system is thus extremely advantageous for the environment. Its range of operation varies between 200 km and 400 km. Although a hydrogen infrastructure comparable to the network of filling stations for liquid hydrocarbons does not exist, setting up a hydrogen supply system of any desired size, e.g. for municipal vehicle fleets, would be technically feasible within a very short time, using for example the steam reforming process of natural gas. In view of the extensive applicability of metal hydrides and the varied demands made on them, the only remaining criteria in the selection of hydride systems are the manufacturing costs and their sensibility to polluted hydrogen with residual gases. All other physical/chemical hydride properties must always be assessed with the specific application in mind. Virtually all hydrides which are still to be developed and whose storage densities are at least 1.5% by weight are suitable for practical operation in vehicles, the only qualifying factors being the manufacturing costs and pollution sensibility. Charts of test data, photographs, and diagrams are appended.

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## HS-021 066

### A STUDY ON REFORMED FUEL FOR AN AUTOMOTIVE GASOLINE ENGINE

The Jet Propulsion Lab. has reported on a method which permits operation of an IC Engine at a super lean A/F ratio by using a hydrogen supplemented fuel. This makes possible a reduction in NOx emissions as well as an improvement in fuel economy. Applying this method to a carbureted three valve pre-chamber engine, a low NOx emission level and improved fuel economy can be expected with a smaller amount of hydrogen because of the combined effects of the hydrogen supplement and the inherent low NOx emission characteristics of the engine. A prototype on-board fuel reformer was developed and laboratory tests were conducted to determine the effects of the amount of reformed fuel on combustion. The results of these tests and the construction of the fuel reforming system are shown in graphs and diagrams. On the Japanese test cycle, an extremely low NOx emission level was attained with relatively good fuel economy. However, in a limited combination of engine size and vehicle weight, engine power was sacrificed somewhat because of the lean combustion. A solution to this problem while maintaining the lower NOx emission level, is to adopt a richer air-fuel ratio and a higher EGR rate. In this approach, the amount of hydrogen must be increased to improve combustion stability. For this purpose, Methanol reforming was introduced whereby the additional hydrogen was supplied without any deterioration in energy efficiency. A series of tables, charts and diagrams are appended, with an outline of the Japanese 10 mode test procedure and an explanation of the basic physical properties for computation of various parameters as at methanol reforming.

by M. Noguchi; T. Bunda; M. Sumiyoshi; J. Kageyama; S. Yamaguchi

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Availability: In HS-021 056

## HS-021 067

### A HYDROGEN-POWERED MASS TRANSIT SYSTEM

A 21-passenger bus is converted to hydrogen, using a Dodge engine which has been modified for high compression operation. Backfiring and nitric oxide pollution formation are controlled by a water injection technique. Hydrogen fuel storage for the experimental prototype is accomplished by two metal hydride containers using an iron-titanium alloy. Data are presented regarding equipment conversion and design, energy resource utilization, economics, and safety. Prototype experiments now under way will help determine potential problems and evaluate overall system potential. A reasonable follow-up program, if no major difficulties are encountered, will be implementation of a small bus fleet for further evaluation.

by Roger E. Billings

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Availability: In HS-021 056

HS-021 068

## REFUELING HYDROGEN TRANSIT FLEETS. PART A - ECONOMICS

The economics of several hydrogen manufacturing, distribution and use strategies are evaluated for a fleet of converted buses for the purpose of setting a guide in selection of feasible methods for refueling. The most attractive alternative is pipeline distribution of hydrogen produced from gasified coal and water for use in FeTi hydride vehicles. A system based on existing technology is estimated to cost midway between the current cost of gasoline (U.S.) and the predicted cost of synthetic gasoline from coal. A hydrogen bus fleet supplied by pipeline will have a lower total cost than systems using other synthetic fuels derived from coal. In circumstances where hydrogen must be distributed by truck rather than pipeline, the lowest cost alternative is to build hydride trailers to supply hydride vehicles. These trailers (FeTi hydride) may then serve as refueling storage after arrival; it is important to bring the refueling depot as near the hydrogen supply as possible. Even though the total cost of such a system is higher than synthetic gasoline it may still be favored in situations where the importance of low emission is considered. Development of a hydride with thermodynamic characteristics similar to FeTi but with a higher hydrogen holding capacity would make hydride tankers (and vehicles) much more attractive economically. Existing materials have a useable storage capacity of around 1.6% by weight; a worthy goal for researchers is 4 weight %. A series of tables comparing fuel costs is appended.

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1977; 20p 15refs  
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HS-021 069

## REFUELING HYDROGEN TRANSIT FLEETS. PART B - DATA.

Data are collected while refueling a prototype hydrogen bus. The refueling operation more severely limits the design of the vehicle tanks than does the discharge condition since the heat transfer must be accomplished in a shorter time. These data indicate that 30 minutes is an attainable refueling period. A significant fraction (40%) of the refueling takes place without heat transfer as the hydride increases in temperature. This characteristic can be enhanced and used to advantage such that a fleet based on an hourly quick-recharge will have a lower operational cost. Sorption characteristics and thermal conductivity for the FeTi hydride used in the vehicle are reported. Appended is a series of isotherms as well as tables giving hydrogen storage data and a hydrogen fleet quick recharge scenario.

by R. L. Woolley; R. B. Beyer; J. Rappleye  
Billings Energy Corp., Provo, Utah  
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1977; 27p 3refs  
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HS-021 070

## ALCOHOLS AND GASEOUS FUELS FROM BIOMASS

Investigations were conducted into the potential and feasibility of generating alternative transportation fuels from biomass (organic plant and animal matter) in the U.S. Emphasis was on substitute natural gas (NG) and ethanol from bioconversion processes such as anaerobic digestion and fermentation. A number of novel projects are currently in progress on a commercial or pilot operation scale which can produce substitute natural gas (SNG) and ethanol at competitive costs in some cases. These include programs at livestock feedlots and sanitary landfills. Heavy reliance is placed on the marketability of by-product streams to secure overall profitability. A table giving estimates of U.S. organic wastes for 1971, and a diagram outlining the processes of anaerobic digestion and of fermentation, are appended.

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1977; 10p

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HS-021 071

## COMPATIBILITY OF AUTOMOTIVE MATERIALS WITH METHANOL FUEL BLENDS

In the search for alternative fuels, the methanol/gasoline blends appear to be a viable answer. While methanol has been used as an automobile fuel for special applications for many years, little is known about the long term effects of methanol on the materials in automobile fuel systems. A series of tests has been made to study the compatibility of automobile fuel system materials with methanol/gasoline blends. Tests have been made using several methanol/gasoline blends including blends with water to simulate moisture pickup by the methanol. The conditions included ambient and elevated temperatures, with and without agitation. Evaluation was based on weight loss due to uniform corrosion and indications of pitting corrosion, stress corrosion cracking, and galvanic corrosion. Methanol and methanol/gasoline blends increase the corrosion rates of most metals over the rates found in straight gasoline. Two areas of potential corrosion problem were determined. The most severe problem was the attack of methanol and methanol blends on ternary plated steels. Methanol and methanol blends also produced severe pitting in aluminum. Agitation did not appear to have a marked effect on the rate of corrosion, and the difference in temperature from 70° F to 120° F did not make an appreciable difference in corrosion rates. Unless corrective measures are taken, it is possible that the use of methanol/gasoline blends could cause severe deterioration to the automobile fuel system if used over extended periods. Figures showing corrosion rates are appended.

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HS-021 072

# INTERNATIONAL SYMPOSIUM ON AUTOMOTIVE PROPULSION SYSTEMS (4TH). VOL. 3. SESSION 7, 9

A collection of 12 papers presented at the Symposium covers various engine configurations and components development. Development of components and subsystems for Stirling engines, particularly the heater head, seals, and control systems, has aimed to commercialize the engine through special market segments and increase specific performance. A D-Cycle Condensable Vapor Stirling Engine has advantages of being a markedly simplified system for power modulation, and a major reduction in the problems of containment of the working fluid. A new regenerator core made from aluminum silicate shows little evidence of chemical attack damage, which used to be the major cause of their failure. Recent automotive Rankine engine development programs have confirmed low emissions advantages, but show fuel consumption levels which are still too high. A third generation Carter Steam System, experimentally installed in a VW Dasher, has performed well in bench tests. A completely integrated compound engine consisting of a diesel engine coupled to a Rankine engine which operates on the exhaust heat of the diesel engine has been designed and is currently undergoing dynamometer testing. Two stratified charge engine processes with a divided combustion chamber, the VW-PCI-process and the VW-PCV-process, are investigated on single-cylinder and four-cylinder engines to evaluate influences of various design and operational parameters on exhaust emissions and fuel consumption. Application of an original stratified charge combustion process to a single cylinder two-stroke 370 cu cm engine has reduced emissions, and fuel and oil consumption. British Leyland dual-chamber three valve stratified charge engines have been designed to reduce pollutants and improve economy. A mathematical model has been developed for compression, combustion, and expansion processes of a stratified charge engine, consisting of an auxiliary combustion chamber with an inlet valve and a main combustion chamber with both the inlet and exhaust valves. An air/fuel metering system has been developed to combine the advantages of premixed combustion, torch ignition, and servo feedback control of the air/fuel ratio to maintain engine operation at the lean limit. Development progress of the unthrottled direct injected Stratified Charge Rotary Combustion Engine Program at the Curtiss-Wright Corp. is updated since the 1974 status report.

Energy Res. and Devel. Administration; North Atlantic Treaty Organization, Com. on the Challenges of Modern Society 1977; 443p refs

Collection of papers presented at the Symposium, Washington, D.C., 17-22 Apr 1977.

Availability: Corporate author

HS-021 073

## DEVELOPMENT OF 40-150 KW STIRLING ENGINES IN SWEDEN AND THEIR APPLICATION IN MINING EQUIPMENT, TOTAL ENERGY SYSTEMS AND ROAD VEHICLES

Development of components and subsystems for Stirling engines, particularly the heater head, seals, and control systems, has aimed to commercialize the engine through special market segments and increase specific performance. Most Stirling engines are of the double-acting type (pistons produce power in both moving directions), and ideally have five cylinders. Design development has been carried out on a V4 engine. A

mean pressure control system regulates output power; main parts of the system are hydrogen storage vessel, hydrogen compressor, control valve block, and a servosystem which controls the position of the control valve. Tests indicate that the power control system acts fast and accurately. The air-fuel control system uses a Bosch K-Jetronic unit for accurate air fuel ratio control. Sliding piston rod seals have proven to be the optimum seal type. The starting system, requiring a preliminary heating period for tubes, has functioned well in testing down to -32° C. Three different low-cost, high performance heater heads have been designed. Stirling engines are characterized by low noise and emissions levels, and multifuel acceptance. Future testing and marketing of Stirling engines will involve mine vehicles, heat pump engines, space heating, domestic hot water production, and city buses. The Stirling engine first cost is assumed to be about 50% higher than that of an untreated diesel engine for the same production volume. Projected operational costs predict a 6% improvement in fuel economy over a turbocharged direct injected diesel engine, and are generally lower for the Stirling engine due to less maintenance and fuel and lube oil consumption. The estimated pay-back time for the difference in fuel cost between Stirling and diesel engines is less than two years.

by Bengt Hallare; Kaj Rosenqvist  
United Stirling, Sweden

Publ. in HS-021 072, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v3

1977; 40p 4refs

Availability: In HS-021 072

HS-021 074

## D-CYCLE VAPOR STIRLING ENGINE

A D-Cycle Condensable Vapor Stirling Engine has advantages of being a markedly simplified system for power modulation, and a major reduction in the problems of containment of the working fluid. The preferred working substance is steam, due to its low cost, availability, and ease of replacement. Steam eliminates a need for the complex roll-sock mechanism or interference-fit piston rod seals for retaining gas within the engine. Power systems can use steam or ammonia as working fluids, and can operate entirely with superheated vapor in a valveless multicylinder double acting engine. Use of steam in a three-cylinder engine with flow-control valves is the preferred operating method. Removal of some vapor allows heat rejection by the condenser. Condensate is injected into the cold space to effect isentropic compression at minimum temperature. Power modulation is simply effected by varying the injection rate. This is an instantaneous method of control and replaces the complex pressurized gas reservoir and pumping system that are currently necessary with gaseous Stirling engines. The vapor engine is predicted to have high brake efficiency. Although it has a slightly lower ideal efficiency than the gas engine, the vapor Stirling's advantages give it a significantly higher practical thermal efficiency for given maximum temperature.

by J. G. Davoud; J. A. Burke, Jr.

D-Cycle Power Systems, Inc., 2541 Stratford Rd., Richmond, Va. 23225

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HS-021 075

## CERAMIC REGENERATOR CORE DESIGN AND RELIABILITY

Chemical attack of the lithium aluminum silicate material used in early gas turbine, ceramic regenerators has been identified as a major cause of their failure. An engineering program was initiated in 1973 to eliminate this failure mode and develop a regenerator capable of a B-sub10 life of 10,000 hours at 800° C. After over 100,000 core-hours of engine durability testing at 800 and 982° C, using diesel fuels and completed since Jan 1974 on new regenerator materials and design concepts, two materials, aluminum silicate and magnesium aluminum silicate, show promise in achieving durability objectives. A regenerator core made from aluminum silicate shows little evidence of chemical attack damage after 7,000 hours of engine tests. Mechanical changes, consisting of elastomer bonded ring gear, stress relieving slots, and rim mounting have contributed to durability improvement.

by C. J. Rahnke

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Availability: In HS-021 072

HS-021 076

## AUTOMOTIVE RANKINE ENGINE DEVELOPMENTS: AN INTERNATIONAL PERSPECTIVE

Recent automotive Rankine engine development programs have confirmed low emissions advantages, but show fuel consumption levels which are still too high. A number of developmental programs have researched and tested Rankine engines since 1970: the U.S. Environmental Protection Agency/Energy Research and Development Administration (EPQ/ERDA) AAPS program; an application to the mine haulage car; the California Steam Bus Project; and the California Clean Car Project. Other programs include DOT's Dallas Transit System Bus Project; the DOT Paratransit Vehicle Project; Carter Steam Engines; and Steam Power Systems' high temperature engine. Automotive steam engines have been researched and tested in Sweden, Australia, and Italy. Inferences drawn about Rankine engines in their current exploratory stage indicate that the engines can meet extremely low pollution limits. Although Rankine engines have demonstrated poor fuel economy, a few of them have yielded peak thermal efficiencies similar to part-load efficiencies of spark ignition internal combustion engines. Lightweight steam engines have been built as light as 2.7 kg/KW. Operating reliability is presently low due to lack of practical design experience and testing. Rankine-powered vehicles can be designed to accept a wide variety of substitute fuels. Overall thermal efficiency can probably be raised from 15% to 20%, to 30% or more, and fuel economy can probably be improved to meet U.S. standards. These improvements would require redesign and development of modified cycles, engines which employ higher steam temperatures, and improved component efficiencies and better system integration.

by Roy A. Renner

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Availability: In HS-021 072

HS-021 077

## DESCRIPTION AND TEST RESULTS OF THIRD GENERATION CARTER STEAM SYSTEM AS INSTALLED IN A VW DASHER.

A third generation Carter Steam System, experimentally installed in a VW Dasher, has performed well in bench tests. Bench tests on the Dasher expander have been used in conjunction with computer simulation to determine fuel economy. The system consists of a two-cylinder reciprocating expander (492 cc) and a variable pressure steam generator (40 atm - 164 atm). Torque and horsepower are varied by varying steam pressure and rpm. Response of the steam generator to varying power demands is rapid. The driver controls the throttle valve opening. The engine is designed to produce a maximum of over 100 gross horsepower at 164 atm and 5500 rpm. Projected fuel economy in the 2,500 pound vehicle over the Federal City Driving Cycle is 24.8 mpg, which compares to the best achieved by a 2,500 pound 1977 vehicle equipped with an automatic transmission. Its idle fuel rate is between 0.17 and 0.2 gallons/hour. The complete 85 hp steam system weighs 345 pounds, fits in the Dasher engine compartment, and is capable of vehicle acceleration from 0-60 mph in 14 seconds. The projected exhaust emissions are below the original 1976 requirements and are a valuable characteristic in the congested city environment. All test results indicate that the engine is a viable candidate as an alternative automobile power plant. Its multi-fuel characteristic will become more valuable as present fuels are depleted. The combustion is also inherently quiet since it is continuous and occurs at low pressure. Engine weight and volume compare well with other engines. Packaging of the steam engine is quite versatile since it is composed of a number of components which do not have a fixed relationship to each other. A fourth generation engine employing a steam reheat cycle and 1250° F steam temperatures is in the final design stage.

by Jay Warner Carter, Jr.

Jay Carter Enterprises, Inc., FM 369, Burkburnett, Tex. 76354  
Publ: In HS-021 072, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 17p 2refs  
Availability: In HS-021 072

HS-021 078

## STATUS REPORT ON ORGANIC RANKINE BOTTOMING CYCLE FOR LONG-HAUL DIESEL TRUCKS

A completely integrated compound engine consisting of a diesel engine coupled to a Rankine engine which operates on the exhaust heat of the diesel engine has been designed and is currently undergoing dynamometer testing. Performance predictions indicate an overall fuel saving of approximately 15% for a typical long-haul truck development, a national annual fuel savings of over 1.8 billion gallons at consumption levels projected for 1980. System components are suitable for vehicular installation and demonstration. Components could be mass produced for a cost which would gain general acceptance of the Rankine-Cycle compound engine. Predicted maximum power is 326.7 horsepower at a diesel speed of 2100 rpm. Primary turbine design is three-stage axial flow running at 60,000 rpm, with a barrel-type enclosure with shaft seals at both ends. Predicted overall efficiency of turbine and gearbox is 75.5%. The gearbox consists of three reductions: two planetary

reductions followed by a final parallel shaft reduction at the output. A soft-type coupling approach is used. The control system controls fluid flow rate and fan speed. A three-cylinder variable displacement feedpump has been developed. Two organic fluid vapor generator cases have been designed and assembled. A six-row radiator is used, along with an air-cooled condenser and a regenerator in the form of a shell and tube heat exchanger. The condenser-radiator fan is a tube-axial design which approaches 70% efficiency. It is driven by a variable ratio belt drive actuated by a hydraulic cylinder.

by E. F. Doyle; R. J. Raymond; S. N. Helekar  
Thermo Electron Corp., Waltham, Mass.  
Publ: HS-021 072, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 46p  
Availability: In HS-021 072

HS-021 079

### DEVELOPMENT STATUS OF THE VOLKSWAGEN STRATIFIED CHARGE ENGINE.

Two stratified charge engine processes with a divided combustion chamber, the VW-PCI-process and the VW-PCV-process, are investigated on single-cylinder and four-cylinder engines to evaluate influences of various design and operational parameters on exhaust emissions and fuel consumption. The two stratified charge engine concepts, based on the 1600 cu cm four-cylinder engine, have been tested in VW Dashers. Special investigations have been carried out with various mixture preparation devices and exhaust gas aftertreatment systems. In single cylinder engine testing of the PCI-process, advantages were demonstrated for a prechamber configuration with a flat connecting port exit and a reduced connecting port cross-sectional area in comparison to earlier designs. While exhaust emissions and fuel consumption are dependent on the degree of stratification in the PCI-combustion-process, the dependence on the mixture strength of the auxiliary mixture in the case of the PCV-combustion-process is not so significant. Investigations of the PCI-concept in Dasher vehicles in combination with a lean thermal reactor resulted in NOx emissions slightly above 1 g/mile. A sufficient margin below the HC-limit was not obtained at reasonably low fuel consumption. Potential for improvements lies in the cold start and hot start phase. Positive effects in regard to emissions and fuel consumptions were demonstrated with the PCV-concept with an intensive heating of the intake mixture by exhaust gas. A 30% fuel economy improvement has been obtained in special investigations with the PCV-concept which was optimized in regard to compression ratio, ignition timing, air-fuel-ratio and mixture formation. However, an oxidation catalyst and exhaust gas recirculation became necessary to keep exhaust emissions within reasonable limits. The NOx reduction below 1 g/mile reduced the fuel economy advantage to approximately 10%.

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Volkswagenwerk AG, Wolfsburg, Germany  
Publ: HS-021 072, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 24p 9refs  
Availability: In HS-021 072

HS-021 080

### TWO-CYCLE STRATIFIED-CHARGE ENGINE

Application of an original stratified charge combustion process to a single cylinder two-stroke 370 cu cm engine has reduced emissions as well as fuel and oil consumption. The two-stroke cycle and direct-injection stratification are advantageous, particularly for part load, where a significant reduction in consumption can be achieved in comparison with the present four-stroke automobile engine. The experimental engine has power output of 40-45 hp/liter, utilizing a chamber and prechamber system and a water cooling process. The engine is equipped with injection timing and a separate oil pump. Five combustion chambers which were tested have high squish effects, which are necessary for good combustion. A conventional spark ignition system was used for testing. Performance results reached 23 hp at 4500 rpm. Hydrocarbon discharge rates are between 2% and 5% of the fuel used; carbon monoxide rates vary between 3% and 6%. Nitrogen oxide discharge rates vary between 1% and 2%. Gas flow under idling conditions is about 0.11 liters per hour for 20 hp. Lubricant consumption varies between 1% and 2% of the oil flow.

by Jacques Pichard  
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Publ: HS-021 072, "International Symposium on Automotive Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 23p  
Availability: In HS-021 072

HS-021 081

### BRITISH LEYLAND EXPERIMENTAL STRATIFIED CHARGE ENGINES

British Leyland dual-chamber three valve stratified charge engines have been designed to reduce pollutants and improve economy. Reduction of nitric oxide is achieved by operating at overall air/fuel ratios of about 20:1 while maintaining efficient combustion in order to improve economy and control hydrocarbon emissions. At part loads, stratification results in improved efficiency as a result of full throttle running. The exhaust manifold consists of a low temperature gas insulated hydrocarbon reactor. Economy is not much affected by pre-carburetor throttling, providing the pre-chamber is over-filled. For the throat size and main chamber configuration used, main chamber mixing on induction is fairly thorough. The main throttle effectively determines pumping losses of the engine and has the greatest influence on the overall air-fuel ratio. Economy tends to improve as throat size is decreased, until combustion noise in the pre-chamber becomes too obvious. Single hold configurations are more economical than multiple throats. Pre-chamber volumes at about 10% are most economical, whereas ability to run lean overall increases at 30% volume. At air-fuel ratios near stoichiometric, the ignition advance required is typically 22° at 3000 rev/m, compared to about 30° for a conventional engine. For operation at current optimum economy, overall air-fuel ratios, the pre-carburetor air-fuel ratio must be over 8:1. Considerable reduction in nitric oxide emissions clearly can be obtained with a modest improvement in fuel consumption over a non-emission controlled

vehicle. California emissions standards should be achievable with a thermal or catalytic reactor.

by J. H. Weaving  
British Leyland UK Ltd., Browns Lane Plant, Allesley,  
Coventry, CV5, 9DR, England  
Publ: HS-021 072, "International Symposium on Automotive  
Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 35p 7refs  
Availability: In HS-021 072

HS-021 082

# **MODELING AND EVALUATION OF COMBUSTION PROCESS OF A THREE-VALVE STRATIFIED CHARGE ENGINE**

A mathematical model has been developed for compression, combustion, and expansion processes of a stratified charge engine, consisting of an auxiliary combustion chamber with an inlet valve and a main combustion chamber with both the inlet and exhaust valves. Mixture formation at the end of the compression process is calculated, and then a simple combustion model is developed to compute the gas temperature, gas pressure, and the rate of formation of nitric oxide (NO) and carbon monoxide (CO) at each crank angle, using the basic energy equation and reaction kinetics for both the auxiliary and main chambers. The same calculations are used for the expansion process. Evaluation of the model is carried out by comparing computed and experimental data, and a satisfactory correlation is observed. A satisfactory agreement has been observed between the computed and measured pressure and temperature time diagrams for both the chambers, except a few discrepancies in temperature diagrams. The equivalence ratio in the auxiliary chamber is computed during compression process by calculating the mass flow through the torch opening. The NO and CO predicted from the model is in close agreement with the measured values, in particular the trend of both the curves plotted against the torch opening area is similar to each other. The analysis of the model for three different torch openings on NO emissions has indicated that increase in torch opening results in higher NO, which may be caused by the higher peak temperature. The developed model may be available for analyzing the performance of a three valve stratified charge engine.

by T. Asanuma; M. K. Gajendra Babu; S. Yagi  
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Devel. Co., Ltd., Wako-City, Saitama Prefecture 351, Japan  
Publ: HS-021 072, "International Symposium on Automotive  
Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 19p 20refs  
Availability: In HS-021 072

HS-021 083

# **A RETROFIT FUEL VAPOR METERING SYSTEM WITH TORCH IGNITION AND MULTIFUEL CAPABILITY**

An air/fuel metering system has been developed to combine the advantages of premixed combustion, torch ignition, and servo feedback control of the air/fuel ratio to maintain engine operation at the lean limit. Premixed combustion is achieved by vaporizing all of the fuel in a heat exchanger using the waste heat of the exhaust gases. Torch ignition is accomplished by means of Fuel Vapor Injector/Igniters which

replace conventional spark plugs and introduce a small quantity of fuel vapor into the ignition region prior to ignition. Lean limit engine operation is the result of continuous monitoring and optimization of the engine power output per unit of fuel input. Implemented with simple, low cost hardware, the system has been retrofitted to four, six, and eight cylinder vehicles. Comparison of the system with conventional metering systems has shown marked improvements in both fuel economy and exhaust emissions.

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Fuel Injection Devel. Corp., 110 Harding Ave., Bellmawr, N.J.  
08030  
Publ: HS-021 072, "International Symposium on Automotive  
Propulsion Systems (4th)," Washington, D.C., 1977 v3  
1977; 33p 1ref  
Availability: In HS-021 072

HS-021 084

# **AN UPDATE OF THE DIRECT INJECTED STRATIFIED CHARGE ROTARY COMBUSTION ENGINE DEVELOPMENTS AT CURTISS-WRIGHT**

Development progress of the unthrottled direct injected Stratified Charge Rotary Combustion Engine (SCRCE) Program at the Curtiss-Wright Corp. is updated since the 1974 status reported in SAE-741206. Emphasis during this period has been on performance improvements in the automotive road load range. Stratified charge direct-injected rotary engines have demonstrated, at representative automobile engine speed and power levels, fuel consumption equal or better than automotive diesel engines. Efficiency levels can be run with a range of fuels which has included gasoline, aircraft jet engine fuels, and diesel fuel. Steady-state untreated HC emission levels within the band of representative automotive engines have been achieved. Vehicular improvements over gasoline engines are expected to be great because of rapid response of a direct injected engine and independence of "power enrichment" settings. The Texaco stratified charge reciprocating engine has demonstrated over 50,000 miles of operation below oxides of nitrogen, carbon monoxide, and hydrocarbon, (NOx, CO, and HC) limits while still demonstrating competitive tank mileage and performance, despite a high exhaust gas recirculation rate. Results indicate that a SCRCE could be built to provide better automotive tank mileage than an automotive type (prechamber) diesel. Diesel-lean automotive road load specific fuel consumption is complemented by rotary engine size, weight and power density significantly better than even carbureted reciprocating engines. This means that gasoline engine performance can be maintained with better-than-diesel fuel consumption. HC emissions levels are controllable and the CO and NOx acceptable at this stage. Further HC emission reductions are believed attainable with increased optimization and greater emphasis on ignition and injection component development.

by Charles Jones; Harold D. Lamping; David M. Meyers;  
Robert W. Loyd  
Publ: HS-021 072, "International Symposium on Automotive  
Propulsion Systems (4th)," Washington, D.C., 1977 v3  
Rept. No. SAE-770044; 1977; 70p 24refs  
Availability: In HS-021 072

HS-021 085

**AUTOMOTIVE FUEL PRICES AND AVAILABILITY**

Using the Stanford Research Institute (SRI) National Energy Model employed in an earlier synthetic fuels study, energy resources in the U.S. have been interpreted in terms of their impact on the future prices and availability of automobile fuel. The model covers all major energy forms, conversion technologies, transportation modes, demand sectors, and U.S. geographical regions. Explicitly, it models supply elasticity, inter-fuel competition, and end-use demands. It treats energy market dynamics such as investment, financing, technological change, demand growth, and resource depletion from the present out to the year 2025. It computes clearing prices and quantities of energy by type and geographical location, using economic and behavioral models of energy use and investment decision making. The following three categories comprise the principal data upon which the model operates: resource data on the availability and production costs of primary resources, described only in terms of marginal cost per unit of production set against cumulative production (imported fuels described only in terms of price, hydroelectric and geothermal energy in terms of annual production); process data related to synthetic fuels production, product refining and distribution, materials transportation, and electric power generation; and demand data for 14 end-use categories in eight geographical regions, estimated for 1975 and projected for 1985, 2000, and 2025. The modeling approach is based on the economic concept of balancing supply and demand at a market clearing price. The SRI model extends this concept to the simultaneous balancing of thousands of supplies and demands that evolve over time and are connected in a complex network, resulting in thousands of market clearing prices, each specifying the economics of a fuel at a particular location and time. The model also extends the economic equilibrium concept to reflect the observation that the market does not respond to price changes and that price differentials for similar products can persist in economic markets. The 1985 cost of regular gasoline to the consumer, for example, is projected to 65 cents/gallon in 1975 currency (\$1.06/gallon in 1985 currency) under the nominal case assumptions of the synthetic fuels study. Projections of gasoline prices are given for the set of sensitivity cases developed for the synthetic fuels study (e.g. nominal case, low import price, high synthetic fuels cost). These projections are striking because they show that for a given case there is little escalation over time and there are relatively small differences in crude oil costs. Surprisingly, changes in the availability of domestic oil and gas have a relatively minor effect on automobile fuel prices. Changes in energy demand growth rates also have little effect on gasoline prices. It should be emphasized that the model used to compute the fuel prices assumes relative stability of long-run expectations.

by Edward G. Cazalet  
Stanford Res. Inst., Decision Analysis-Energy Dept., Menlo  
Park, Calif. 94025  
Rept. No. TID-27218; 1976; 48p 5refs  
SRI Proj. 5038.  
Availability: NTIS

HS-021 086

**MOTORCYCLE CRASHES: A LEVEL TWO STUDY**

Statistical information from police records about motorcycle crashes in New South Wales was gathered for a three-month

period in 1976 to help further research and decisionmaking measures to reduce frequency and severity of such crashes. Study of the crashes revealed the following accident characteristics: commonly occurring in late afternoons, usually young male adults; head injuries predominant; major of nonfatal accidents involving another vehicle but almost half the fatal ones not; and occurring in urban areas marked by speed limits and at other than intersections. Newly licensed riders and riders of large motorcycles were involved in more crashes than might have been expected from population data. Among licensed rider-owners of motorcycles, there was significant interaction between these two variables in describing level of involvement. Daytime headlamp usage on motorcycles was strongly linked with greater safety in the crash studied. Examination of multivehicle and single vehicle crashes indicates that daytime headlamp usage per se was probably the main reason for the greater safety. Univer: daytime headlamp usage is unlikely to be achieved through persuasion, but a law will probably be well received by motorcyclists. Study data are presented in tabulated form. Appendices present a list of variables coded in the study, and data on motorcycle systems and crash costs.

by Rodney G. Vaughan; Keith Pettigrew; Jill Lukin  
Dept. of Motor Transport, Traffic Accident Res. Unit, New South Wales, Australia  
1977; 104p 29refs  
Availability: Corporate author

HS-021 087

**THE HISTORY OF THE AIRFLOW CAR**

The first streamlined Chrysler Airflow car has proved to be a milestone in automotive design and development, although sales were disappointing. Chrysler engineer Carl Breer was responsible for development of the concept in model year 1934 through 1937. Streamlining as a design principle had roots in 19th Century hydrodynamics and aerodynamics. Breer conducted windtunnel tests during developmental phases of Airflow design, which would involve a change from form-box-like car shapes. Five body sizes were marketed in 1934: four with eight cylinder engines and the smallest, a six cylinder, under the DeSoto name. The Airflow car, characterized by more comfortable ride, more passenger space, a rounded lines of a single stressed-steel body shell, sold poorly probably because of its total newness and its plain, round front-end design. Later cosmetic changes failed to increase sales. Soon, however, other companies began to design models based on principles of Chrysler Airflow design, with great commercial success. Ford's Lincoln Zephyr, General Motors 1951 "fastback design," and Volkswagen's "Beetle" were patterned after the original Chrysler design.

by Howard S. Irwin  
Publ: Scientific American v237 n2 p98-104, 106 (Aug 1977)  
1977  
Availability: See publication

HS-021 088

**EMISSION TEST CYCLES AROUND THE WORLD**

Emission control certification test cycles philosophy, design and operation, as practiced in the U.S., Japan, and Europe, influence automobile design processes. Auto emissions studies began in 1956, with the Automobile Manufacturers Assoc

pm emissions collected in three phases: cold transient, cold stabilized, and hot transient. Measurements are calculated to determine mass measurements of a given pollutant collected during each of the three phases. The CVS-CH cycle is quite sophisticated compared with Japanese and European test cycles. Japan's emission control certification tests are based on two distinct 10-mode hot and 11-mode cold-start cycles. It does not simulate a road route, rather it tests for emissions as an engine undergoes a brief set of typical urban transient conditions. Europe's ECE-15 regulation cycle incorporates a cold-start driving cycle, an idle CO test, and a crankcase emission evaluation to test a composite of vehicle operating conditions rather than a route-generated simulation. It is low-speed and has no oxides of nitrogen (NOx) requirement. A worldwide common certification procedure, although it would upgrade testing quality and avoid duplication of effort, is probably not feasible at this time. Test correlations have proved difficult due to vehicle and test variations, even with back-to-back tests using identical procedures.

by Dennis J. Simanaitis

Publ: Automotive Engineering v85 n8 p34-43 (Aug 1977)

1977

Availability: See publication

HS-021 089

### PHOTOGRAPHY IMPROVES DIESEL INJECTION

High-speed photography through a transparent piston crown has contributed to better understanding of the diesel combustion process, which leads to optimization of the mechanics of fuel injection for increased economy and reduced smoke emissions. Tests have been carried out on a single cylinder version of a commercial vehicle engine having a toroidal combustion chamber shape and a compression ratio of 17.8:1. Photographs were taken from the underside. Test results indicate two keys to improved combustion: good geometrical distribution or adequate coverage of fuel jets in the combustion chamber, and good local mixing of fuel droplets and air in the jets. Differing combinations of number and scale of the fuel jets and swirl level cause different distributions of the fuel jets in the combustion chamber, with consequent variations in combustion quality. The exhaust smoke level tends to decrease with an increasing number of injection nozzle holes and with increasing swirl ratio. Cylinder pressure rate of heat release, mean gas temperature, and fuel injection rate, studied with respect to the crank angle for 3-hole, 4-hole, and 5-hole nozzles, shows poorer combustion in the 5-hole nozzle. The Hino Micro Mixing System (HMMS), evaluated by photographic study, shows good thermal efficiency, a high burning rate, a lower level at the first rise in heat release rate, better fuel economy, and a shorter entire combustion period relative to a conventional system. Several different ignition processes were observed, sometimes occurring simultaneously. Further studies of ignition patterns and combustion tuning of direct in-

Availability: See publication

HS-021 090

### CRASHWORTHINESS THROUGH CONTROLLED DEFORMATION

Energy-absorbing front frame members that undergo accordion-like collapse in response to impact represent Audi's theory and practice of "autogenous deformation" in development of lightweight construction crashworthiness. Controlled deformation optimizes the tradeoff of energy dissipation and crush distance. Buckling force of folding depends essentially on the square of channel wall thickness, on the yield stress, and also on the rate of deformation. If impact stress exceeds buckling stress, the characteristic uniform folding initiates at the point of impact. Conversely, if impact stress is less than buckling stress, the channel tends to begin its autogenous deformation at some arbitrary weak point. Critical buckling stress, in actual practice, is approximately half of theoretical stress because of variations in a channel's sheet metal material. Width of a channel appears to be essentially uninvolved with buckling force. In the Audi 5000, energy-absorbing channels are free-standing members extending from passenger-compartment tunnel to front bumper mounts. Channels are fabricated from mild steel, incorporate forward motor mounts, and are played outward slightly in consideration of oblique encounters with impact. Channels deform as much as 30 cm and absorb some 70% of impact energy. Integrity of the passenger compartment is retained by stiffening in doors. A 30 mph frontal barrier crash of an Audi 5000 resulted in projected buckling and left the passenger compartment relatively intact.

by Dennis J. Simanaitis

Publ: Automotive Engineering v85 n8 p44-6 (Aug 1977)

1977

Availability: See publication

HS-021 091

### AN UPDATE ON THREE-WAY CATALYSIS

Recent investigations on three-way catalysis encompass selection criteria, crucial rhodium levels, poisoning, and other studies exploiting the three-way approach. Current research and development areas include study of the parameters of converter input and conversely, the effects of converter byproducts on the environment. Another research priority is development of a means of catalyst selection. Widening of the three-way window is accomplished by progressive air injection. Three-way catalysts are generally chosen on the basis of their selectivity toward oxides of nitrogen reduction, particularly in stoichiometric or slightly oxidizing environments. The most common catalytic combination in three-way use is platinum/rhodium with a rich rhodium proportion. Screening aspects to be considered with three-way candidates are static and dynamic A/F ratio dependence; temperature dependence; thermal aging; and poisoning by lead, sulfur, or oil-borne phosphorus. Mechanisms of progressive air injection can be

described in three stages: an initial reducing environment; a second zone with relatively stoichiometric oxygen content; and a third zone where oxygen is superstoichiometric and efficient control of hydrocarbon and carbon monoxide prevails through oxidation. Intentional modulation of the A/F ratio tends to widen the operating window of three-way conversion. Current development questions include whether mine-recovery ratios of platinum and rhodium can support efficient conversion; what products into and out of three-way converters are harmful; and whether three-way systems will be as durable as other automotive subsystems.

Publ: Automotive Engineering v85 n8 p50-7 (Aug 1977)  
1977

Based on SAE-770196 and SAE-770197 (both part of SAE-SP-414), SAE-770298, SAE-770365, and SAE-770366.

Availability: See publication

HS-021 092

### TRUCK DISC BRAKES: INCREASED STOPPING CAPABILITY?

Recently developed truck disc brakes and linings give up to 50% longer life than comparable drum brake linings. Disc brakes stop trucks in slightly shorter distances with less variation among stops. Improvements are due to higher average torque through stop due to increased fade resistance; stable torque characteristics on each wheel due to disc brake pressure/torque linearity; ability of the brake to continue to perform under arduous loading conditions; and driver confidence. Friction material development should be based on linear temperature characteristics and speed sensitivity, because analysis of the exaggerated dynamometer torque trace shows the most important portion to be the temperature sensitivity characteristics or "saddle." The rotor developed for the truck disc brake is of a ventilated design, in pearlitic cast iron. Durability, tested by the Jennerstown Mountain Test Procedure, measured disc brake lining life at between 50,000 - 150,000 miles. With all-wheel disc brake installation, increased durability can be anticipated as compared with the drum brake, for the same compliance level. With a heavy duty disc/drum combination, any brake system adversities are manifested in the disc brake, therefore durability cannot be predicted. With a medium duty disc/drum combination, full system durability will be less than pre-FMVSS 121 by virtue of overall effectiveness.

Publ: Automotive Engineering v85 v8 p58-66 (Aug 1977)  
1977

Based on SAE-770667, by Peter H. Raves. Presented at West Coast Meeting, Vancouver, 8-11 Aug 1977.

Availability: See publication

HS-021 093

### AUTOMOBILE CONSUMER INFORMATION CRASH TEST PROGRAM, VOL. I

Calspan's crash test program is intended to generate experimental test data on recent intermediate size automobiles in areas of damage susceptibility, crashworthiness, and repairability, and to demonstrate the capability of existing simulation models for predicting dynamic responses of vehicles and occupants. The full-scale crash testing program included frontal barrier and car-to-car front-to-side and front-to-rear impacts in 22 tests of 1973 and 1974 models of Plymouth Satellite and Ford Torino vehicles. Much of the requested data generated

within the crash test program are of questionable value for comparative evaluations and rating of vehicle collision performance. Side and rear impact testing for comparison and ranking of crashworthiness and damageability performance of different vehicle make models should be accomplished with identical "bullet" vehicles such as a moving barrier. Crash test data indicate little difference between the two makes of cars with respect to crashworthiness performance, but they appear to differ in terms of damageability based on cost-to-repair estimate comparisons. A 5 mph increment between the speeds of the Phase 2 high speed barrier crash tests appears to be too fine to produce significant differences in test results. The vehicle structure and occupant response simulation efforts must be regarded as inconclusive with respect to having demonstrated the feasibility of using predictive techniques as the basis for evaluation and rating of automobile crashworthiness performance. The structural models in their present form have no specific provisions for including energy absorbing bumper characteristics. Static test methodology for determination of component force-deflection characteristics for input to the vehicle structural response models requires considerable experience with vehicle structures and collapse modes. Experiments and exploratory simulations should be conducted to obtain refined values of some of the model input parameters for the test dummies that currently are highly uncertain. Consideration should be given to modifying the restraint belt algorithm to eliminate the present limitation to either zero or infinite friction between the belts and the occupant.

by N. E. Shoemaker; M. O. Ryder; N. J. DeLeys  
Calspan Corp., Buffalo, N. Y.

Publ: Highway Safety Literature v77 n2 (Feb 1977)  
1977; 11p 5refs

See also HS-802 010.

Availability: Corporate author

HS-021 094

### EFFECT OF LEGISLATED LOWERING OF THE DRINKING AGE ON FATAL HIGHWAY ACCIDENTS AMONG YOUNG DRIVERS IN ALBERTA, 1970-1972

A three-year investigation conducted to determine effects of drinking age legislation in Alberta, Canada, on alcohol-related involvement in crashes of young drivers concludes that 1971 legislation which lowered the drinking age from 21 to 18 years effected an increased incidence of young drivers involved in fatal alcohol-related crashes. Alberta coroners' files were used as the data base. Percentages of alcohol-impaired drivers involved in accidents for the 15-19 year-old bracket increased by 118% from 1970 to 1972, while an increase of 60% was found for 20-24 year-old drivers. Liquor sales increased in 1971, indicating consumption by a larger group. Change in police reporting practices is discounted as a reason for increased accident involvement by alcohol-impaired youths.

by Gerda Bako; Walter C. MacKenzie; E. S. O. Smith  
Publ: Canadian Journal of Public Health v67 p161-3 (Mar/Apr 1976)

1976; 8refs

Availability: See publication

tank, the easily-explodable tank was produced for eight years due to the fact that assembly-line machinery was already tooled. Ford Company lobbied against change in NHTSA safety standards which would require a change in tanks. Estimates indicate 500-900 burn deaths in Pintos due to gas tank explosions. Models produced in 1977 incorporated a few minor alterations, (namely a one-dollar, one-pound, plastic baffle), but better improvements have not been made due to Ford's cost-benefit analysis. Pinto crash tests have resulted in ruptured gas tanks for each of over 40 tests made at over 25 mph. Estimated cost of gas tank improvements to reduce deaths is \$11. However, Ford has contended that additional production costs would decrease sales and damage the auto industry.

by Mark Dowie

Publ: Mother Jones v2 n8 p18-24, 28-32 (Sep/Oct 1977)  
1977

Availability: See publication

HS-021 096

#### **MVMA MOTOR VEHICLE FACTS AND FIGURES '77**

A 1977 motor vehicle handbook provides factual information on production/registration, use and owners, and economic impact. Data are presented in text, tables, and graphs. The section on production/registration covers facilities of motor vehicle manufacturers, factory sales, parts and accessories, and production. Also outlined are recreational vehicles, registrations, retail sales, and retirement. The use and owners section includes drivers, emissions, energy consumption, and farm vehicles. Also detailed are fleets, government ownership, highway fatalities, and highways. Intercity travel, ownership, personal transportation, and purchasers are covered. Information is included on purposes of usage, school bus transportation, shipments of goods, and statistics on vehicle miles of travel. The economic impact section presents data on businesses, employment, exports and imports, and financing. Also presented are gross national product contribution, highway trust fund, materials consumption, and payrolls. Personal consumption expenditures, sales, sizes and weights, and taxes are detailed. An index is included.

Motor Vehicle Manufacturers Assoc., 300 New Center Bldg.,  
Detroit, Mich. 48282

1977; 100p

Availability: Corporate author

HS-021 097

#### **DEPARTMENT OF TRANSPORTATION BUDGET PROGRAM ANALYSIS OF FY [FISCAL YEAR] 1978 DOT PROGRAM BY POLICY AND RD&D MANAGEMENT OBJECTIVES. LEVELS FOR FISCAL YEARS 1976, 1977, 1978**

A six-section informational synopsis of the total budget program of the Department of Transportation (DOT) is intended

through 1978, including the 1979-1980 Administration's budget program is indexed and summarized in terms of programs, objectives, achievements, and expenses. RD and D Management Program Analyses (TST), and Policy and Management Program Analyses (TPI), are summarized, the latter including socioeconomic research program analyses and grant program analyses. Transportation safety program analyses are also presented.

by Robert L. Paullin; Ira Dye; Phillip H. Bolger  
U.S. Dept. of Transportation, Office of the Secretary, 400  
Seventh St., S.W., Washington, D.C. 20590  
Rept. No. DOT-OST-77-1; 1977; 466p  
Final Rept. for Calendar Year 1977.  
Availability: NTIS

HS-021 098

#### **RELATIONSHIPS BETWEEN WHOLEBODY VIBRATION AND MORBIDITY PATTERNS AMONG INTERSTATE TRUCK DRIVERS**

The hypotheses that certain physical disorders develop with undue frequency among interstate truck drivers and that some of this excess morbidity is due to the wholebody-vibration factor of their job, have been tested by extracting and comparing morbidity data available in the periodic, certification examination records for 3,205 active interstate truck drivers and 1,137 active air traffic controllers. Chi-square tests of the 24-year incidence rates of some medical conditions for industry-representative truck driver populations and sedentary comparison groups revealed a number of statistically significant differences in group-specific morbidity patterns. Biodynamic strain, microtrauma, and intraluminal/intra-abdominal pressure fluctuations are known to be produced by truck vibrations have been postulated as being at least partially responsible for development of certain musculoskeletal, digestive, and circulatory disorders among interstate truck drivers with more than 15 years of service. The combined effects of forced body posture, cargo handling, and improper eating habits along with wholebody vibration cannot be ruled out in considering contributory factors for such truck-driver disorders as vertebrogenic pain syndromes, spine deformities, sprains and strains, appendicitis, stomach troubles, and hemorrhoids. Appendices include a physical examination form for interstate truck and bus drivers, a medical examination form for air traffic controllers, and a worksheet for organizing physiological and morbidity data.

by George J. Gruber

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Inst. for Occupational Safety and Health, Div. of Biomedical  
and Behavioral Science, Cincinnati, Ohio 45226  
Contract CDC-99-74-22

1976; 60p 22refs

Availability: GPO

HS-021 099

**PERCEPTUAL FACTORS AND MEANINGS OF  
SYMBOLIC INFORMATION ELEMENTS. VOL. 1,  
EXECUTIVE SUMMARY**

by King M. Roberts; Ernest W. Lareau, Jr.; Daniel Welch  
Federal Hwy. Administration, Offices of Res. and Devel.,  
Washington, D.C. 20590  
Rept. No. FHWA-RD-77-64; 1977; 33p  
For abstract, see HS-021 100, Vol. 2, Technical Report. Rept.  
for the period 1 May 1976-30 May 1977.  
Availability: NTIS

HS-021 100

**PERCEPTUAL FACTORS AND MEANINGS OF  
SYMBOLIC INFORMATION ELEMENTS. VOL. 2.  
TECHNICAL REPORT**

A laboratory evaluation of 108 symbolized and printed message traffic signs representing 19 information situations in which symbols might be effective has been conducted, measuring sign efficiency by means of five independent variables. Each study situation contained 5 to 15 signs, including, generally, one printed message sign. Thirty-two subjects viewed the signs, and collected data indicated how quickly subjects could identify sign content, how rapidly they could formulate a sign meaning, whether their meaning was correct, time required for meaning formulation, and how certain they were that the meaning they supplied was correct. Subjects also ranked signs according to preference. An efficiency index was calculated for each sign based on the summed values of the five variables for that sign. The index permitted a relative comparison of the performance of signs within each message group. Recommendations are made for signs of the following meanings: university, school bus stop ahead, bike lane, no left turn on red, no right turn on red, no turn on red, men working, and information center. Recommendations are also made for the following sign meanings: yield ahead, stop ahead, dip, bump, rough road, base gravel, soft shoulder, truck crossing, flagman ahead, and minimum and maximum speed limits. Usefulness of certainty data in sign efficiency research proved questionable. Meaning latency data reflected the subject's facility for providing logical meanings for the symbols. Study results suggest a set of general symbol signing principles whose use may facilitate optimum sign effectiveness: simplicity, visual contrast, spatial orientation, and dominant elements. Other design considerations are abstract symbolism, physical and temporal orientation, specificity, and message order. Appendices present experimental signs, instructions to subjects, and analysis of variance summaries for mean latency and tachistoscopic data.

by King M. Roberts; Ernest W. Lareau, Jr.; Daniel Welch  
Federal Hwy. Administration, HRS-31, Washington, D.C.  
20590  
Rept. No. FHWA-RD-77-65; 1977; 138p 4refs  
Final Rept. for 1 May 1977-30 May 1977. Vol. 1, Executive  
Summary, is HS-021 099  
Availability: NTIS

HS-021 101

**NATIONAL FUNCTIONAL SYSTEM MILEAGE AND  
TRAVEL SUMMARY. 1976 NATIONAL HIGHWAY  
INVENTORY AND PERFORMANCE STUDY**

U.S. mileage and travel data for 1976 are presented in tabular form, arranged by state for rural, small urban, and urbanized areas. Mileage and travel density characteristics are tabulated for 1975, whereas mileage by jurisdiction and connecting link data are reported only for the 1980 systems. Data are presented in 10 sections. The first summarizes mileage by state and functional system for 1975 and 1980. Functional systems are defined as arterial, collector, or local. The second summarizes daily vehicle-miles of travel by state and functional system. Miles of streets in each urbanized area by functional system are tabulated in the third section. Daily vehicle-mile of travel in each urbanized area by functional system are summarized next. The fifth section presents a data summary of density characteristics. Section six shows 1975 mileage at travel density. Section seven presents 1980 functional system mileage by jurisdiction. Section eight gives a 1980 urban connecting link summary. Mileage of realigned Federal-aid highway systems is presented by state. The last section lists urbanized areas. A list of definitions and terminology is included.

Federal Hwy. Administration, Procedural Devel. and Special  
Studies Branches  
1977; 222p  
Availability: Corporate author

HS-021 102

**SIGNS AND MARKINGS FOR LOW VOLUME  
RURAL ROADS. FINAL REPORT**

Warrants and guidelines for warning and regulatory signs and markings in the "Manual on Uniform Traffic Control Device" are evaluated for functional, economical, and aesthetic applicability to low volume rural roads (average daily traffic less than 400 vehicles). The roads were classified by system (Federal, state, or county controlled) and type of surface (paved and unpaved). Using a modified form of driver task analysis these classes of roads were then analyzed as to the travel characteristics to determine the required level of warning and regulatory signs and markings needed for satisfactory operation and safety. The analysis led to guidelines for the application of stop signs, curve warnings, and passing zone signs and markings. The guidelines were validated by testing 27 driver reactions to the proposed signs and markings. Stop signs should be placed on low volume rural roads intersecting paved highways, provided that the low volume road serves it or more residences, has an average daily traffic of 50 or more and/or is five miles long or longer. Curve signs should be placed in advance of all curves with Q angles of 4° or more on paved roadways, and 60° or more on unpaved roadways unless it can be shown that the posted speed limit is 35 mph or less, or the combination of normal approach speed and safe curve speed requires a perception/reaction/deceleration distance of less than 300 ft. Advisory speed plates should be used in conjunction with curve warning signs when the safe curve speed is 5 mph below that speed warranting a curve sign. As for no passing zones, a "passing hazardous" warning sign should be placed to mark such sections of road, and should contain the number of miles for which the condition exists. Or, a double narrow line may be used. Appended are



series of analyses and comments on sections of road in Ark., Okla., La., and Tex., the forms for data reduction and analysis or rural signing and marking, and the questionnaire used.

by N. E. Walton; J. M. Mounce; W. R. Stockton  
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Station, Tex. 77843  
Contract DOT-FH-11-8249  
Rept. No. FHWA-RD-77-39; 1977; 148p 33refs  
Availability: NTIS

HS-021 103

## COMMERCIAL VEHICLES IN COLLISIONS INVOLVING VEHICLES PARKED OR STOPPED ON HIGHWAY SHOULDERS. SPECIAL STUDY

A pilot study of In-Depth Accident Investigation Reports involving commercial and noncommercial vehicles parked on shoulders of highways covers accidents during nine calendar years, 1967 through 1975. Its purpose is to alert interested parties as to the causes and results of moving vehicles colliding with those parked on shoulders of interstate and other highways and to stress the importance of motorists stopping on highway shoulders only for purposes relating to motor vehicle breakdowns or other emergency situations. Constant evaluation of causes of specific types of accidents is necessary, through in-depth accident investigations. A series of tables and graphs depict distribution and classification of accidents by type and result. One accident is analyzed with numerous photographs. Of the 58 accidents investigated, involving vehicles parked on highway shoulders, 47 happened on interstate highways; negligent and nonemergency parking of vehicles by both commercial and noncommercial drivers were contributory factors in 21%; drivers dozing at the wheel and allowing their vehicles to travel onto the paved shoulders was the primary cause factor in 31 of the 58 (53%). Fifty-two occurred between 11:31 P.M. and 5:30 A.M.; 90% were rear-end type collisions. Recommendations are to study the need for a contrast in texture of highway shoulders from that of the traveled portion of the highway to the point of producing a "rumble effect" to alert dozing drivers that they are leaving the travelled portion of the highway, and induce a safe recovery; a study of the present signing and mapping of rest areas to determine whether adequate information is being given; and a need for additional pedestrian advisory information warning them to stay away from the traveled portion of the road unless actually engaged in the repair of the vehicle.

Federal Hwy. Administration, Bureau of Motor Carrier Safety  
1977; 28p  
Availability: Bureau of Motor Carrier Safety, Federal Hwy.  
Administration, Washington, D.C. 20590

HS-021 104

## MOBILITY OF PEOPLE AND GOODS IN THE URBAN ENVIRONMENT: MOBILITY OF THE HANDICAPPED AND ELDERLY

An evaluation methodology for the analysis of alternative transportation improvements for the handicapped and elderly is based on the ability to incorporate the qualitative attributes of transportation systems which are particularly significant to the handicapped and elderly groups: comfort and convenience, security and safety, and accessibility. Issues addressed include the types of transportation problems faced by the handicapped

and elderly, types of physical transportation improvement options which are implementable to meet their needs, a workable methodology to quantify user benefits, analysis techniques for comparing alternative transportation improvement options, and a realistic approach in the planning of demonstration projects which are capable of meeting expected goals. The barriers within transportation modes which are severe problems for the handicapped are listed. The most severe problems of subways are long stairs, high steps, need for rapid movement, need to ride standing, long walking distances, movement in crowds, baggage, overhead grips, and fear of physical safety. Problems with public buses include high steps, need to ride standing, need for rapid movement, movement in crowds, getting on and off, long walking distances, baggage, overhead grips, and fear of physical safety. The most important problem with taxis is the personal cost. Problems associated with car services are personal cost, and need for rapid movement. The problem with car or minibus systems for the handicapped is the need to ride standing. Private cars also provide problems of the need for rapid movement and long walking distances. The relevant work done in the identification of user problems and travel demand includes an evaluation methodology and a case study example for illustration. The issues of demonstration projects planning are considered, and guidelines offered for the design of demonstration experiments which can produce results that are capable of objective analytical interpretation.

by J. Falocchio; S. Santimatanedol; L. Horwitz; B. Stephanis  
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Polytechnic Inst. of New York, 333 Jay St., Brooklyn, N.Y.  
11201  
Contract DOT-OS-30095  
Rept. No. DOT-TST-77-43; TR-75-503; 1977; 156p 104refs  
Availability: NTIS

HS-021 105

## PUBLIC INFORMATION CAMPAIGNS ON RESTRAINT SYSTEM USAGE: AN ANNOTATED BIBLIOGRAPHY

This annotated bibliography on restraint system public information campaigns provides 54 citations grouped in three sections: U.S. studies, Canadian studies, and studies from other countries. Within each section, the literature is divided into three additional parts: general literature about campaigns, not pertaining to a particular program; literature regarding specific campaigns which have been evaluated; and citations on specific campaigns which have not been evaluated. Within each part items are in chronological order. In some cases, annotations have been taken directly from the authors' abstracts, occasionally revised or with additional comments; generally, however, the comments and opinions are those of the compiler of the bibliography. No effort is made to assess the quality of the campaign design or evaluation. While it is impossible to draw any conclusions from this bibliography, a few positive trends may be noted, such as the realization of the need to evaluate public education campaigns. The need for campaigns, because of their expense, is still debated; however, it is generally agreed that well designed and executed programs do influence people's attitudes.

by Ann C. Grimm  
University of Michigan, Hwy. Safety Res. Inst., Huron Pkwy.  
and Baxter Rd., Ann Arbor, Mich. 48109  
Rept. No. UM-HSRI-77-31; 1977; 23p  
Availability: Teknecron, Inc., 4701 Sagamore Rd.,  
Washington, D.C. 20016

HS-021 107

**VENTING AIRBAGS FOR SEAT APPLICATIONS**

The airbag can be useful as temporary seating in vehicles since it can be deflated and stored in a small volume when not required. Such an application has been proposed for the transport helicopter. When fitted with valves to relieve pressure, the airbag provides seat, spring and damper in one light and simple combination. Studies were made with a small bag of similar size to a car seat cushion, measuring load vs. pressure, load vs. deflection, transient tests to establish the natural frequency of the bag and load, drop tests with the valves venting. Additional tests were made with a six-seat passenger module in which the effective support area was found to be double that in the case of the single-seat bag. Results of the tests are displayed in graphs. Conclusions were that a crude multi-seat module, allowing full leg reach of 0.4 m or so, provides temporary stowable seating with a natural heave frequency in the region of 3.5-4.0 Hz; this is comparable with that of a car seat, but damping is only about 5% critical, except in impacts when venting is possible. Improved valve response would be helpful, but it does not seem possible to set blow-off pressure at load pressure, since an impact or even a shift of the occupant might result in the collapse of the bag. Rocking of the whole module may be excited by pitch or roll of the vehicle since the natural frequencies of these are in the same range, namely 1.5 - 2 Hz. The inconvenience of an air supply and valve has to be recognized. Moreover, shaping of the seat is more desirable than with a conventional design, due to the natural convexity of the bag. A study of restraints is necessary and is being undertaken.

by C. W. Stammers

Publ: IMechE 1977 Automotive Engineer p24-7 (Jun/Jul 1977)

1977; 8 refs

Availability: See publication

HS-021 108

**HOW MANY TRAFFIC DEATHS ARE ACCEPTABLE?**

The major causes of auto accident fatalities are drunk drivers, high-speed driving, defective cars, "defective" drivers, and bad roads. The annual death toll of about 30,000 in alcohol-related accidents could be cut to almost nothing by national prohibition, which was tried once and did not work. Liquor multi-billion-dollar industry, and Federal and state governments get much tax money from liquor sales. The arrest of drunk drivers is ineffective, as a suspended driver is soon back on the road. The 55-mph speed limit imposed during the energy crisis in 1973-74 resulted in a dramatic drop in auto-accident deaths and proved that speed is responsible for a large number of driving fatalities. Poor design and/or workmanship in the structure of a car, and neglect of maintenance by the owner are also causes of accidents. Mandatory car-safety inspections are a solution employed by some but not all states. Problem drivers bear a responsibility. The reluctance of the Federal government to press for increased safety standards is criticized. Speed control devices have been recommended, as well as a reduction in the mileage markings of speedometers from top speeds of 180 down to, at most, 100 mph. Most improvements which would save lives are not being made because of cost; money spent in gradual improvement of a

stretch of highway has progressively fewer results in terms of lives saved, raising the question "How much is a life worth?"

by John L. Kent

Publ: Highway Patrolman v41 n6 p10-1, 44 (Aug 1977)

1977; 3p

Availability: See publication

HS-021 109

**CHARACTERISTICS OF TODAY'S YOUTHS AS INDICATED BY THEIR INCLINATIONS FOR VEHICLES. AN INTERIM REPORT**

In Japan today the bosozoku, or hot rodders, can be divided into two groups: those of eastern Japan, characterized by the competition in driving techniques while driving around i groups, and those in western Japan, who repeat circus-like ci cuit-racing games such as quick starting, quick stopping, turning and double turning in a relatively confined area. These activities have led to group vandalism and violence. A study was made to determine, through comparison between the bosozoku and high school students of the same age bracket (16-18) the actual condition of the access to and use of motor vehicles, the areas of their interest, their behavioral characteristics and personality traits forming a background factor in their interest in motor vehicles, and to identify characteristics of the bosozoku. A detailed description of the survey groups and method precedes a discussion of the findings. Major findings were that while the bosozoku obviously have access to a tomobiles, an unexpectedly large number of high school students—1/3 of the total—also had access to cars. The kinds of magazines read differed, with the bosozoku reading more a tomobile magazines, high school students involved with a tomobiles reading more comic magazines, and non-automobile inclined students reading more study and hobby magazine. Clear differences were observed between the automobile inclined and non-automobile-inclined in terms of their interests and behavioral characteristics; the younger group of bosozoku seemed to exist apart from the other groups just as did the non-automobile-inclined group of high school students. The analysis, which includes in tabular form the data obtained, still at an interim stage.

by Yasuhisa Nagayama; Mitsuo Nagamachi; Toshisada

Nagaoka; Akihiro Suzumura

Publ: International Assoc. of Traffic and Safety Sciences Re:

v1 p23-41

1977; 4 refs

Availability: See publication

HS-021 110

**A STUDY OF A LARGE SCRAMBLE INTERSECTION. AN INTERDISCIPLINARY APPROACH TO THE SUKIYA-BASHI INTERSECTION**

A large intersection near the Ginza district in Tokyo, Japan was studied to evaluate the scramble system. A detailed analysis was made of pedestrian and vehicular traffic in all parts of the intersection on various days, at varying hours of the day in various directions and in diagonal crossing. Comparison was made between the volume of traffic for a specific period 1973, before the adoption of the scramble system, and similar period in 1974 afterwards; congestion increased in 1974 but accidents decreased. Some confusion occurred when

pedestrians unaccustomed to the system tried to cross with the green signal for cars. The time allotted to pedestrian crossing was apparently not enough to permit all to cross the zone completely, but lengthening of the present signal cycle would not solve the problem. A bottleneck at one corner of the intersection requires further study. Proposals included changes in the present signal cycle and more reasonable split of the signal turns, an "island" for pedestrians to be built within the intersection, one of the vehicle lanes to be diverted to a pedestrians' sidewalk, a transparent tubelike footbridge to be set up. Interviews were conducted with pedestrians who had been caught in the intersection when the signal changed; none showed any resentment, though some were concerned at having started across too late. Human factors governing the pattern were desire to cross, recognition of signals, size of the crowd crossing at one time (tendency to follow without looking at signal), familiarity with traffic environment, and pedestrians' personality. One-third of those interviewed were critical of the intersection; the majority spoke favorably of it. A further survey was taken of pedestrians regularly using this intersection and another conventional, non-scramble type; of these, 60% preferred the scramble type. The scramble system works most effectively at intersections where vehicular and pedestrian traffic are both heavy with left and right turns by vehicles; where volume of through traffic is not great in proportion to the total, and average running speed very low; where the width of the street is 50 feet (about 15 meters) or less, and the sidewalks available for pedestrians to wait are wide; where there is sufficient lighting; and where at least one of the streets is desirably designated for one-way traffic. At this intersection all these conditions do not apply, however, and it was concluded that the intersection is too large in scale for the scramble system, even though pedestrians seem to prefer it. Adoption of the two-phase system would solve the problems of delay and congestion. A number of diagrams, charts and tables provide the data obtained.

by Namiki Oka; Masaaki Asai; Kiyoshi Okada; Akira Tsujimura; Motoo Nakajima; Yoji Niitani; Kazu Horiuchi; Hiroshi Miyakawa; Richard I. Emori; Shuhei Aida; Yoshio Ikeda; Takemochi Ishii; Yoshio Oba; Yukihide Okano; Fuyuhiko Okabe; Yasuhei Oguchi; Chikashi Nakanishi; Masaki Koshi  
 Publ: International Association of Traffic and Safety Sciences  
 Res. v1 p42-71 (1977)  
 1977

Availability: See publication

HS-021 111

## ANALYSIS OF THE SAFETY OF TRAFFIC FROM THE STRUCTURAL STANDPOINT

Current efforts to promote traffic safety must include consideration of the character and needs of the community background as well as improvements in technology. Safety and smooth traffic flow are prerequisites for road structure. An accident case is cited involving the question of safe upkeep of roads, with two differing court decisions regarding liability for damages. A public road should be properly structured and responsibly administered, with a compensation system in case of accident to minimize private loss. There should not be a choice between paying damages or making an investment for safety. Driving behavior must correspond to changes in environmental conditions, both natural and in traffic flow; traffic regulations should anticipate such possible changes. Improvement of driving skill through training is possible; the driver's physical, mental and psychological condition also affects his

capability. Tables are provided showing the ratio of accidents according to type of road, weather conditions, time of day, area, etc. A large proportion of accidents occur in major cities, often at intersections, tunnels, and crossings. For more effective countermeasures, further analysis of the traffic condition is required.

by Kiyoshi Okada  
 Publ: International Association of Traffic and Safety Sciences  
 Res. v1 p72-80  
 1977; 1 ref  
 Availability: See publication

HS-021 112

## IMPLICATIONS OF VISUAL PERCEPTION IN ROAD TRAFFIC SAFETY

In the interest of traffic safety, research efforts should be directed toward the problem of how a driver sees and interprets a complex moving scene rather than measurements of the basic, static visual abilities of the driver. Recent development of the eye-marker camera system has provided an effective tool for studying visual search-and-scan patterns of drivers. Eye movements and static eye positions can be mapped to the driver's visual scene with a method by which the eye-spot from the driver's eye and his visual scene are superimposed, and this picture is then recorded on film. This method demonstrated that experienced drivers tend to focus fairly steadily on a point in the moving visual field straight ahead where objects on the roadway appear stationary, depending on peripheral vision for determining lane position, while novice drivers switch from busy searching, large eye-movement travel distances and fixations on irrelevant cues to alternate sampling near and far, relying more on foveal vision. Familiarity with the route played an important role in visual searching strategy. On a straight uninterrupted road, looking straight ahead and relying on peripheral vision to note entering vehicles and pedestrians is best. Legibility of road signs depends on letter characteristics, brightness contrast, and illumination, and visibility on the brightness contrast of word to sign and sign to background. Disregard of road signs may be caused either by the driver's perceptual limitations or his deficient motivation. Environmental factors such as road conditions, visibility, and traffic density do not greatly affect sign registration; tests have shown that if drivers were highly motivated to detect signs they could register every sign even under extreme conditions. Lateral movement across the line of sight is easier to perceive than longitudinal movement, coming directly towards or going directly away. The subjective scale of velocity based on sensory impressions is called the "mental speedometer," and is cued by the flow pattern of the surrounding scene, the note of the engine and its echoes, the feeling of acceleration or deceleration, etc. Studies show that a driver tends to use this mental speedometer more often than the vehicle's speedometer when making speed adjustments in traffic, and not always accurately. Subjects tended to underestimate velocities, particularly higher ones. Dangerous effects caused by reliance on this mental speedometer have important practical implications for the design of entrance and exit ramps of freeways. Velocity judgment may be manipulated by introducing structured patterns on the road surface; a pattern of traverse bands of which spacing decreases exponentially can most effectively influence a driver to slow down. A head-up display system is under development, to project the

vehicle's speed onto the windscreen where the driver may be aware of it without having to look down.

by Kaoru Noguchi  
 Publ: International Association of Traffic Safety Sciences Res.  
 v1 p81-90 (1977)  
 1977; 26refs  
 Availability: See publication

## HS-021 113

# THE RELATION BETWEEN MAN-VEHICLE TRAFFIC FLOW AND FUEL CONSUMPTION OF AUTOMOBILES

Driving techniques, traffic flow, and standards of automobile performance are all factors in minimizing fuel consumption. Improvements in the fuel consumption rate should be made in such a way that the acceleration performance, maximum velocity, habitability, riding comfort, and safety in accordance with the design concept of the automobile are in perfect balance. A better fuel consumption rate may be achieved by improvement of engine thermal efficiency, optimization of fuel control, reduction of engine mechanical loss, reduction of transmission loss, curb of vehicle-body air resistance as well as tire rolling resistance and curtailment of vehicle weight. Methods of representing the fuel consumption rate vary in the way and for what purpose the measurement has been taken. They include: test course fuel consumption, which represents the quantity of fuel consumed at different velocities measured when driving at a fixed velocity without acceleration or deceleration along a flat-paved test course; drive fuel consumption rate, obtained when running along a regular road amid public traffic flow; model drive fuel consumption rate, obtained by simulating a running mode on a regular road with a test course; 10 Mode and 11 Mode fuel consumption rates, determined by equipping the test automobile with a chassis dynamometer to measure air polluting component gases, 10 Mode representing a hot start subjected to a congested urban area and 11 Mode a cold start subject to the commuting time from a suburban into an urban area; high-speed fuel consumption rate, measured when an automobile is running along an expressway; acceleration fuel consumption rate, performance expressed by the time required to cover 400m under rapid acceleration from a standstill; and economical drive fuel consumption rate, whose object is to define a rate at which the vehicle is driven with the intention of minimizing fuel consumption. A number of graphs set forth test data. Fuel consumption rate is significantly influenced by traffic density. A comparatively smooth traffic flow with a minimum of stops and starts is economical in fuel consumption, as well as important to energy-saving political measures. Exhaust control measures are roughly divisible into two categories: the oxidation catalytic converter method and the noncatalytic method based principally on lean side burn. Each method involves increase in vehicle weight. No remarkable reduction of the fuel consumption rate due to the 1975, 1976 Control Standards in Japan has been noted.

by Masahide Sano; Yasuhei Oguchi  
 Publ: International Association of Traffic and Safety Sciences  
 res. v1 p91-100 (1977)  
 1977; 4refs  
 Availability: See publication

## HS-021 114

# UPGRADING OF THE MACK DIESEL ENGINE LUBRICANT SPECIFICATIONS

Field testing and laboratory testing of oils SAE 30, 10W/30, and 15W/40W indicated the superiority of several of the newer oil formulations for the Mack engine requirements. Satisfactory results were obtained with both mono- and multi grade oils. The 15W/40 oil gave the overall best test results (improved oil consumption, reduced insoluble level and reduced oxidation) this oil also gave satisfactory oil pressure. The 10W/30 oil produced operating oil pressure lower than normal based on comments by the truck operators involved. The multiviscosity oils, in general, gave better bearing lubrication than straight grade oils. Visual observation showed copper through the lead/tin overlay at 100,000 miles with EO-H, the existing Mack oil specification, and no copper at 200,000 miles with the new EO-J multiviscosity oils. Both monograde and multigrade EO-oils gave better oil consumption in laboratory tests than was obtained with EO-H oils. Field test oil consumption with multigrade oils was generally better than with straight grade. A modified multicylinder engine test (T-5) was developed in the testing program. This test procedure utilizes an intercooled 32 hp ET-AZ673 engine which is typical of the new engines being marketed to satisfy the 10 gram nitrogen oxides and hydrocarbon brake specific emission level. The test severity has been increased by using a 600-hour test period without oil drain. In addition to a demerit limit on ring belt deposits, as was required in the T-1 procedure for the EO-H specification, oil viscosity increase and oil consumption levels are limited for T-5 performance. The minimum requirements for an oil to qualify as meeting the EO-J specification are as follows: separate tests required for mono- and multi-grade oils; forwarding two pistons, preferably the best and worst, to Mack's Technical Support Laboratory for a rating check; average oil consumption for the entire 600-hour test not to exceed .00 pounds per horsepower-hour during any cycle; engine oil viscosity change at 210° F not to exceed 5 centistokes from the lowest to the highest measurement; and piston demerit not to exceed 600 as rated by the T-5 procedure.

by W. R. Alexander; L. T. Murphy  
 Mack Trucks, Inc.  
 Rept. No. SAE-760718; 1976; 10p 2refs  
 Presented at Automotive Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.  
 Availability: SAE

## HS-021 115

# FIELD EXPERIENCE OF EXTENDED DRAIN INTERVAL IN DIESEL LUBRICANT PERFORMANCE

Four engine oils, three new candidate formulations and one current product, were tested in three different types of truck diesel engines using 100,000-mile drain intervals. Periodic samples from each test vehicle were analyzed. After 100,000 miles engines were dismantled, inspected and rated. Drain intervals (for diesel engines in line-haul truck services) much longer than currently recommended by manufacturers is possible with current engine and oil technology. Also, oil change intervals can be extended from current practice. Other conclusions reached are as follows: variance in severity, largely as a function of design, of diesel engines in similar service showing correlation of Total Base Number of used engine measured by ASTM D664 with copper corrosivity, the li

then remaining relatively constant. Analytical data from the used oil samples and engine inspection reports for the four oil formulations are provided. Some suggestions are made with regard to running field tests of this type and include the following: use as many vehicles as one can afford (a minimum of three per test oil); keep all test participants as fully informed as possible (delegate as many of the test functions as possible); reduce the record keeping to a minimum simple routine by use of custom designed forms, etc., wherever possible; and fit sampling and inspections as closely as possible to the routine schedule of the fleet operation.

by E. F. Boone; F. E. Didot  
Suntech, Inc.  
Rept. No. SAE-760719; 1976; 19p 5refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 116

## TRENDS IN JAPANESE DIESEL ENGINES AND THEIR LUBRICATION

Since the oil crisis and air pollution problems arose in 1973, the diesel car is again being considered as an economical, low polluting car (estimated production of 5,000-6,000 cars in 1976). It is expected that vibration and noise problems which have made the car unpopular will be overcome in the near future. The volume of diesel engine oils sold in Japan (1971-1975) has averaged about 250,000 kl per year. The decrease in diesel oil in 1975 (20% less than 1973), however, was less than that noted for gasoline engine oils (more than 30%). There has been no significant change between 1971 and 1975 in percent sales volumes of API-classified diesel engine oils. At present the most popular oil change intervals being used for CD, CC, and CB oils are approximately 10,000 km, 6,000-8,000 km, and 4,000-6,000 km, respectively. Currently, the trend has been toward extending these intervals by about 30%. Since 1970, improved filters designed for long life and easy replacement have been gaining popularity. As oil prices have increased, the major bus and truck fleets have begun using the improved filters. Oil drain intervals for filter-equipped trucks have been extended to 50,000-60,000 km, without changing oil performance level. A survey of diesel engine oils representing 90% of the total Japanese market show the following results: additives are mainly compounded with calcium detergents, ashless dispersants, and zinc dithiophosphates; average zinc content is 0.10% for CD, 0.08% for CC, and 0.06% for CB oils; and average sulfated ash is 1.7% for CD, 1.2% for CC, and 0.8% for CB oils. Although diesel engine builders refer to the API performance classifications, their own in-house engine, bench rig and long-term field tests are sometimes specified. The engine builders in general have not noted any reduction in fuel or oil consumption when using multi-grade diesel engine oils. Most builders are satisfied with current zinc dithiophosphate content found in surveyed oils, most have not specified a sulfated ash content, and most desire a 6 to 7 TBN (ASTM D 664) level for API CC quality oils. The builders also stress thorough vehicle maintenance for optimum performance of oil filters and recommend viscosity grades from SAE 10W to SAE 40. The Japanese regulations on diesel engine exhaust emissions were established on 20 May 1974. All engine builders have investigated methods to reduce emissions (e.g. exhaust gas recirculation and retarded injection timing). Future trends of Japanese diesel engines include increased engine output to reduce exhaust emissions, insulation of the engine en-

closure to minimize noise, and application of direct injection systems for fuel economy. Future trends in diesel lubricants include increased thermal and oxidative stability, and improvements in extreme pressure and antiwear properties.

by Kiyoshi Sakamoto  
Nippon Oil Co.  
Rept. No. SAE-760720; 1976; 12p  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 117

## LUBRICATION REQUIREMENTS OF EUROPEAN AUTOMOTIVE DIESEL ENGINES

Comprehensive investigations were made by Co-ordinating European Council (CEC) Investigation Group IGL-5, established in mid-1973 to examine the specific lubrication requirements of European high-speed diesel engines (rated speed greater than 1,800 rpm) to assess the suitability of existing standardized test methods of evaluating lubricant-related requirements. A CEC Working Group studied bore polishing in supercharged engines and development of a realistic lubricant test method, emphasizing the need for a valve train pitting/scuffing test, covering the requirements of diesel engines. Further studies were initiated by the IGL-5 Group into the need for test methods covering oil thickening in IDI engines, ring sticking, and factors influencing oil drain periods. Trends in the diesel engine industry demanding higher lubricant performance have been identified by the IGL-5 Group. First, top ring groove temperatures and oil sump temperatures will progressively increase, giving further emphasis to the problems of oil thickening and ring sticking. Second, oil drain periods will be extended to 20,000 km or longer for direct injection engines. Oil drain periods for indirect injection engines are, in most cases, presently limited to 5,000 km due to oil thickening problems. There are strong desires on the part of manufacturers to extend these periods to be in line with common gasoline engine practice (up to 10,000 km). Finally, oil consumption patterns of diesel engines will be reduced. Manufacturers have indicated a desired reduction of about 50%.

by C. R. Knight; H. Weiser  
Perkins Engines Co.; Mobil Oil Co., Ltd.  
Rept. No. SAE-760721; 1976; 27p 13refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 118

## CYLINDER BORE POLISHING IN AUTOMOTIVE DIESEL ENGINES - A PROGRESS REPORT ON A EUROPEAN STUDY

Test results are reported from multicylinder production engines and from single-cylinder laboratory engines concerning cylinder bore polishing, evidenced by areas of bright mirror finish. It can lead to excessive oil consumption and ring and bore scuffing and seizure, and has become a significant problem for manufacturers of high-speed diesel engines. Tests have shown that choice of lubricant can influence its occurrence. Work has been carried out by Co-ordinating European Council (CEC) Investigation Group IGL-5 in supercharged single cylinder diesel engines to develop a suitable standard

method to evaluate lubricants with respect to bore polishing. Correlation needs to be demonstrated with established lubricant performance in multi-cylinder engines. To date, the results of work in the Petter AVB engine have been rather inconclusive and further studies are in progress in three laboratories to fully evaluate the potential of the method. A tentative test procedure in the Caterpillar 1Y73 engine has produced encouraging results in that it appears to rate lubricants in the same direction as do the turbo-charged multicylinder engines. Repeatability and reproducibility have not been fully acceptable, and work is currently in progress in three laboratories to determine whether these factors can be improved, principally by testing under less highly rated operating conditions. It is emphasized that the studies to date have been based, for the most part, on two high performance diesel lubricants, of significantly different viscometric characteristics and additive contents, which have been shown to give different degrees of polishing in turbo-charged diesel engines. Once the preliminary stages of the investigation are completed, its scope should be widened to include a greater variety of lubricant types.

by J. V. D. Wilson; J. R. B. Calow  
Edwin Cooper and Co., Ltd.; Shell Res., Ltd.  
Rept. No. SAE-760722; 1976; 11p 4refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 119

#### LUBRICATING OIL CONTAMINATION IN INDIRECT INJECTION DIESEL ENGINES

A work program has defined how the rates of lubricating oil contamination in indirect injection diesel engines vary with different design parameters (load, speed, coolant temperature, lubricating oil temperature, combustion chamber design, combustion chamber position, air/fuel ratio, exhaust smoke, crankcase blowby) and various engine running conditions. Lubricating oil is contaminated by combustion products, which is a feature peculiar to indirect injection engines; and this contamination can lead to severe oil thickening and eventual lubrication failure. Results of the extensive testing show the following factors to be the major influence on the rate at which the lubricating oil is contaminated by combustion soot: emitted smoke, engine speed, fuel injection timing, combustion chamber design (the higher the mixing rate employed, the greater the soot input rate), and piston attitude (the dynamic lateral position of the piston relative to the combustion chamber probably being the most significant factor). Substantial improvements are predicted in the contamination problem by close attention to combustion chamber design and piston and ring behavior. Great benefits would accrue from an oil formulation which exhibits less viscosity change and no thixotropy effects when heavily contaminated with soot particles. An alternative would be an oil with the ability to hold soot particles in controlled agglomerations capable of easier filtration. Oil suppliers might feel that this latter feature is a retrograde step, but the idea is seriously offered as a means of simplifying the engine designer's task.

by I. B. Smith; A. R. Chowings  
Perkins Engines, Ltd., Res. and Product Devel. Div.  
Rept. No. SAE-760723; 1976; 16p 4refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 120

#### A TURBOCHARGED DIESEL ENGINE TEST FOR EVALUATING RING STICKING TENDENCIES OF HIGH QUALITY DIESEL ENGINE OILS

The use of a European 5945 cc (363 cubic inch displacement, CID) engine and 300-hour test procedure was evaluated as a means of predicting the ring-sticking tendencies of crankcase oils in turbo-charged diesel engines. Correlative data are provided with the Caterpillar OL-1 Test, a procedure used for many years to evaluate crankcase oils of Series 3/MIL-L-2104C/API Series CD performance. The oils evaluated in this study were in the Series 3/MIL-C/CD or higher SHPD category and included the following: Oil L (used for initial procedure development of caterpillar Superior Lubricants Series 3 performance, found to be associated with ring sticking in the field); Oil H (of Series 3 standard also, not found to be associated with ring sticking in the field); Oil S (contains an additive treatment designed to provide anti-ring sticking performance superior to that given by currently available Series 3/MIL-C/CD oils, while retaining attributes of High Performance Diesel Oils (HPD) particularly with respect to the ability to minimize oil thickening in small indirect diesel engines, designated as an SHPD oil); Oil HH (same family as Oil H, but upgraded for testing in the initial procedure development and later adopted as the standard for the procedure refinement); and REO-203 (not part of the test development, but the 5945 cc test result on it is included to give a wider understanding of the test severity level as it had been established as the CRC Reference Oil for the Caterpillar I-G and Mack T1 tests). It became a requirement that any engine test to evaluate additive treatment of higher performance level should consistently show Oil H to be superior to Oil L, with respect to protection against piston ring sticking. The 5945 cc engine tests identified the ring-sticking tendencies of Oil L and Oil H in the same manner as their known field histories. Progress is reported on test development and refinement. Test results show the superior performance of SHPD Oil S in minimizing piston ring sticking. Such a standard of performance is in accord with current needs and future engine design trends of European engine builders. The test engine is relatively small in relation to engines in other multi-cylinder tests such as the OL-1 and T-1. Most engine parts are readily available through a large dealer network. With the level of severity of the current procedure and range of parts available, it would appear that the test could serve the oil industry well into the future. More work needed, however, under the current test conditions to evaluate oils of known field performance and to develop data on repeatability and reproducibility.

by C. H. Knight  
Lubrizol International Labs.  
Rept. No. SAE-760724; 1976; 15p 7refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-021 121

#### AN ANALYSIS OF THE VARIABLES ASSOCIATED WITH THE ROLLER SHEAR FATIGUE TEST [FLEXIBLE URETHANE FOAMS]

An in-depth study of the roller shear fatigue tester as a use apparatus for measuring fatigue properties of flexible urethane foams was undertaken. Included in the study was the effect foam thickness, foam density, and the number of flex cycles

cles. Some comments are made with regard to future research in this area. The British Standard and the proposed ISO fatigue test, like the roller shear, are excess energy tests in that the force is independent of the load-bearing property of the foam. High and low ILD foams are tested the same way, yet their end uses are not identical. The designed indentation should be considered. A stool seat designed for 10% indentation should not be tested identically to a car seat designed for 50% indentation. A beneficial research program should include adjusting the mass of the rollers to achieve the given designed indentation, or, in other terms, the amplitude of the cyclic strain is determined by the intended end use and corresponding stress is applied.

by William A. Ashe  
BASF Wyandotte Corp.  
Rept. No. SAE-760725: 1976; 6p 2refs  
Presented at Automobile Engineering Meeting, Dearborn,  
Mich., 18-22 Oct 1976.  
Availability: SAE

HS-802 253

### **A STUDY RELATING TO SEAT BELTS FOR USE IN BUSES. FINAL REPORT**

A study of farm labor buses, school buses, and transit buses in the State of California with respect to the installation and use of seat belts in both new and used buses was conducted. Included in the study were visits, inspections and in-depth discussions with bus owners, operators, maintenance personnel, seat manufacturers, belt manufacturers, and bus manufacturers for the purpose of obtaining information on all of the required aspects and viewpoints of bus design (including seats and seat belts), production, fabrication, purchase, operation and maintenance because of the impact of these items on both new and used buses. A search was conducted of all types of literature pertaining to buses, bus safety, and seat belts as well as operation and economics of the various types of buses and related seat belts. An extensive bibliography is appended. It is recommended that seat belts not be installed in any category of bus in California until adequate research and design are completed to justify a factual decision in either direction. Sufficient research has not been accomplished to date. Also, research on seat belts in automobiles and aircraft has proven that the entire seating system must be considered as a unit to afford the maximum protection for the passenger. The 1975 statistics from the State of California indicate that school buses without seat belts are 16.2 times more safe than automobiles, most of which are equipped with seat belts. This ratio is based on the comparison of the millions of vehicle miles driven each year in California.

by C. R. Ursell  
Southwest Res. Inst., San Antonio, Tex.  
Contract C-206-75/76  
Rept. No. PB-264 369; 1977; 134p 291refs  
Rept. for 1976.  
Availability: NTIS

System (FARS), information on fatal motor vehicle traffic accidents occurring during the first six months of 1976 is presented. FARS is a computerized data base containing information on fatal motor vehicle traffic accidents occurring in the 50 states, the District of Columbia, and Puerto Rico. The sources utilized for FARS information include the following: police accident reports, driver license files, motor vehicle registration files, vital statistics, and state highway department records. These sources are occasionally supplemented by emergency medical service reports and hospital records. Each accident in FARS contains at least one fatality and has occurred on a trafficway. The FARS definition of a fatality is one which occurs within 30 days of a motor vehicle traffic accident and as a result of the accident. All other definitions are those contained in the American National Standards Institute (ANSI) Manual on Classification of Motor Vehicle Traffic Accidents. The file is estimated to be 98% complete. When interpreting the data, it is important to remember that statistics can be deceiving. Statistics obtained from the data often summarize complex relationships into a small set of numbers. Tables provide the following data: occupants and non-occupants by survival status and land use; accidents and fatalities by state and month; accidents and fatalities by state and land use; occupant and nonoccupant fatalities by state of accident; state of accident by vehicle registration location: in-state driver license; state of accident by vehicle registration location: out-of-state driver license; occupant and nonoccupant fatalities by sex and age; drivers by sex, age and vehicle body type; accidents and fatalities by time of day and day of week; urban accidents and fatalities by time of day and day of week; rural accidents and fatalities by time of day and day of week; vehicles by first harmful event and body type; accidents by first harmful event and class trafficway; accidents by land use, roadway alignment and grade, and manner of collision; accidents by adverse surface conditions and light conditions; state of accident by period of time from accident to notification of emergency medical service; state of accident by period of time from accident to arrival of emergency medical service; state of accident by period of time from notification to arrival of emergency medical service; and accidents and fatalities, by state, for the first six months of 1975 and 1976. Some of these data are duplicated in tables and graphs.

National Hwy. Traffic Safety Administration, Information Systems Div., Washington, D.C. 20590  
1977; 64p  
Availability: Corporate author

HS-802 385

### **AN ANALYSIS OF PROJECT IMPACT ON ULTIMATE MEASURES OF PERFORMANCE. ANALYTICAL STUDY 1, 1973. PUERTO RICO ALCOHOL SAFETY ACTION PROJECT**

An analysis of the impact on ultimate measures of performance of the Puerto Rico Alcohol Safety Action Project (PASAP), a Federally funded demonstration effort which seeks to establish the potential effectiveness of various countermeasures aimed at reducing the incidence of alcohol-related and injury-producing motor vehicle accidents, is presented.

in its first full year was an analysis of statistical trends over time, using a multiple forward stepwise regression model where a cause-and-effect relationship is posited by theory. The 514 fatal crashes that occurred in 1973 were 74 fatal crashes below the projected number and 77 crashes less than the average for heavy alcohol-related (A/R) crashes that occurred in the 1968-1972 period. Fatal crash data when adjusted for the number of drivers, cars, miles driven and population, showed a decrease as compared to the baseline period. In retrospect, this decline follows the 25-year decreasing trend, except when fatalities are expressed per 100,000 population. Other ultimate performance measures indicated declines in terms of heavy A/R involvement with the exception of multivehicle fatal crashes, which showed an increase over the baseline period. In terms of the projected estimates as compared to the actual number, the total of all crashes, all traffic injuries, pedestrian injuries and fatalities showed a statistically significant decrease. This trend follows through in the registered A/R injury and property-damaged crashes reported by the police, which were considerably below the 1968-1972 average. Further indications of reduced drunk driving in Puerto Rico is the decreased level of BAC (blood alcohol concentration) of the fatally injured driver (0.11 for 1968-1972 and 0.07 for 1973). Results of two roadside surveys showed a decrease from 38% in 1972 to 34% in 1973 for drivers having BAC less than 0.01 and from 7% to 5% for the seriously-impaired drivers with a BAC of 0.10 or more. The frequency distribution showed a statistically significant change. The average BAC of drivers interviewed during the surveys was lowered from an average of .024 in 1972 to .019 for 1973. Demographically speaking, the profile of driver deaths and DWI (driving while intoxicated) suspects was comparable. Occupation distribution showed that the housewives and clerical workers (mostly women) are represented less among DWI arrests than their involvement in nonfatal A/R crashes may justify. Also unjustified is the large number of skilled workers arrested for DWI. This group represents 34% of the arrest sample and only 17% of drivers involved in registered A/R traffic accidents. Progress has been made by the ASAP in informing the general public about drinking. The cost-effectiveness analysis showed net savings of \$18.4 million to society through the reduction of all heavy A/R traffic accidents. In conclusion, the study of ultimate performance measures during 1972 in Puerto Rico provided support for the hypothesis that increased probability of arrest can deter socially harmful behavior as exemplified by drinking and driving.

by Levon Yeganiantz

Puerto Rico Traffic Safety Commission, San Juan, P.R.; Appu Kuttan and Assoc., 1374 Ashford Ave., San Juan, P.R. 00907  
Contract DOT-HS-160-2-251  
1974; 209p 23refs  
See also HS-802 386--HS-802 389.  
Availability: Reference copy only

HS-802 386

#### **AN EVALUATION OF ASAP POLICE PATROLS, 1973 ANALYTIC STUDY 3. PUERTO RICO ASAP [ALCOHOL SAFETY ACTION PROJECT]**

An evaluation of the 1973 police patrol activities of the Puerto Rico Alcohol Safety Action Project (PASAP), a Federally funded demonstration effort which seeks to establish the potential effectiveness of various countermeasures aimed at reducing the incidence of alcohol-related and injury-producing

about \$280,000 to operate 12 police patrols in 10 of the 11 (exception being metropolitan San Juan area) police traffic areas in Puerto Rico. These patrols operate in full force on weekends (Friday, Saturday, and Sunday) and at half strength on weekdays during the ASAP hours of 6 P.M. to 2 A.M. It is concluded that the ASAP patrols countermeasure has effectively contributed to a significant reduction (32%) in the heavily A/R (alcohol-related, BAC (blood alcohol concentration) of .10 or more) fatal crashes within the ASAP patrol areas during 1973 as seen from a significant correlation between crash reduction and DWI (driving while intoxicated) arrest-accident ratio. In terms of cost-benefit analysis, the ASAP patrols program has contributed to saving of \$20 (in terms of reduction of heavily A/R fatal crashes for the ASAP hours) for every ASAP dollar spent in the program. The ASAP patrols program has also been effective in increasing by 49% the perception of the risk of arrest among drivers in Puerto Rico. The ASAP patrols have also contributed to a significant reduction (24%) in the proportion of heavily A/R drivers on the roads of Puerto Rico in 1973. All 10 ASAP areas overall have performed better than the non-ASAP area. The ASAP patrols have performed better than the regular patrols in terms of implied consent refusal rate (25% for ASAP vs. 39% for regular), DWI conviction rate (79% vs. 69%), and patrol hours per DWI arrest (12 hours vs. 113 hours). The ASAP patrols are arresting the right individuals as indicated by the similarity of the profiles of drivers arrested and killed. The catalytic effects of ASAP patrols on regular patrols include a 40% increase in the latter's DWI arrests. It is recommended that the patrol program be continued, that all patrols should be positively motivated and encouraged to improve their performances in terms of DWI arrests and contacts, that the Puerto Rico Traffic Safety Commission might consider designating the three alcohol patrols in the non-ASAP area as ASAP patrols in an attempt to improve their very poor performance; and that the patrols be asked to implement a monthly patrol scheduling (patrol hours, days, and locations) plan based on up-to-date accumulated accident and arrest data and following the concepts of "evolutionary operation."

Puerto Rico Traffic Safety Commission, San Juan, P.R.; Appu Kuttan and Assoc., 1374 Ashford Ave., San Juan, P.R. 00907  
Contract DOT-HS-160-2-251  
1974; 153p 1ref  
See also HS-802 385, and HS-802 386--HS-802 389.  
Availability: Reference copy only

HS-802 387

#### **AN EVALUATION OF THE REHABILITATION COUNTERMEASURE ACTIVITIES 1973. ANALYTIC STUDY 6 [PUERTO RICO ALCOHOL SAFETY ACTION PROJECT]**

An evaluation of the 1973 rehabilitation countermeasure activities of the Puerto Rico Alcohol Safety Action Project (PASAP), a Federally funded demonstration effort which seeks to establish the potential effectiveness of various countermeasures aimed at reducing the incidence of alcohol-related and injury-producing motor vehicle accidents, is presented. Of the 364 persons who were reported as having entered ASAP rehabilitation in 1973, 37.9% were problem drinkers and 62.1% were social drinkers. Out of these two groups, only 210 social drinkers successfully completed the DWI (driving while intoxicated) improvement course of three-four hour sessions given in a period of three weeks, and had their licenses reinstated.



disburbed. ASAP activities resulted in providing the rehabilitation program with a steady growth of the problem drinker-drivers. Since the Rehabilitation Program was in its initial stage, neither cross tabulation nor statistical tests could be performed with the 1973 data. A control group could not be established since the Law provides for rehabilitation of all diagnosed problem drinkers. Subsequently, two comparison groups, matched for BAC (blood alcohol concentration), sex, age and driving record, are being developed. This will include the group that dropped out of rehabilitation which will be matched with a comparable group of those who completed rehabilitation. It will also include a group of convicted DWI offenders during the first part of 1973, when rehabilitation was not available. This group will be limited to the convicted offenders with a BAC of 0.20 at the time of arrest.

Puerto Rico Traffic Safety Commission, San Juan, P.R.; Appu Kuttan and Assoc., Evaluation Team, 1374 Ashford Ave., Santurce, P.R. 00907  
Contract DOT-HS-160-2-251  
1974; 94p 20refs  
See also HS-802 385, HS-802 386, HS-802 388, and HS-802 389  
Availability: Reference copy only

HS-802 388

# **ANNUAL REPORT, JANUARY-DECEMBER 1973. PUERTO RICO ALCOHOL SAFETY ACTION PROJECT**

The annual report for 1973 of the Puerto Rico Alcohol Safety Action Project (PASAP), a Federally-funded demonstration effort which seeks to establish the potential effectiveness of various countermeasures aimed at reducing the incidence of alcohol-related and injury-producing motor vehicle accidents, is presented. The first section deals with background information and provides data on the following: community description (physical description, fatalities and fatal accidents 1973 (514 fatal accidents resulting in 575 fatalities of which 228 were pedestrians), laws and regulations, legislative and administrative changes); statement of project objectives, description of countermeasure program (enforcement (special alcohol patrol units, special alcohol pedestrian patrol units, breath analysis, video tape evidence collection); assistance to prosecutors; licensing and driver registration; pre-sentence investigation; evaluation, diagnosis and referral; legislative and regulatory; and public information and education (regional ASAP educators, lecture-orientation program, public information campaign)). A second section deals with overall ASAP progress and presents information in the following categories: annual report, abstract; fiscal review; and catalytic effects. Next to be discussed is countermeasure activity, an analysis of which is presented in the following sections: enforcement; judicial; assistance to prosecutors; judicial, pre-sentence investigation; rehabilitation services; licensing and driver registration; legislative and regulator; public information and education, regional

See also HS-802 385--HS-802 387, and HS-802 389  
Availability: Reference copy only

HS-802 389

# **FINAL ANALYSIS OF THE IMPACT OF PUERTO RICO ASAP [ALCOHOL SAFETY ACTION PROJECT] ON THE TRAFFIC SAFETY SYSTEM. ANALYTICAL STUDY 4, 1972 THROUGH 1975. FINAL REPORT**

A final analysis of the judicial system with respect to the Puerto Rico Alcohol Safety Action Project (PASAP), a Federally-funded demonstration effort which seeks to establish the potential effectiveness of various countermeasures aimed at reducing the incidence of alcohol-related and injury-producing motor vehicle accidents, is presented. Data on the disposition of DWI (driving while intoxicated) court cases in Puerto Rico for 1974-1975 indicated that the conviction rate of all superior court parts was 63.7% of disposed cases. More than 50.0% of all cases pleaded guilty at arraignment. Among contested cases, the conviction rate was only 18.9%; acquittals were 53.0%; and dismissals 27.9% for calendar year 1974. It was felt that the large number of DWI arrests contributed to the increase in absolute number of DWI convictions but led to a decrease in percentage of conviction. In nearly all instances, the judges accepted the diagnosis and recommendations of the ASAP probation officers based on pre-sentence investigations. License suspensions were used in two-thirds of the cases. Fines amounting to about \$100 on the average remained the primary sanction for DWI offenders in Puerto Rico. The major punishment for DWI offenders was short-term incarceration for those who could not put up the bail, and fines in the form of high legal fees charged by private lawyers for those who chose to plead not guilty. If a defendant pleads not guilty and does not have a BAC (blood alcohol concentration) of .20 or more on his/her record, the chances of acquittal, particularly if the defendant has a good lawyer who will cost \$500 to \$1,500 are more than 80%. The backlog of cases was maintained at a steady level of 3,500 cases starting in the middle of 1974 through the middle of 1975. The change of DWI case jurisdiction from superior courts to district courts will cut down the backlog within a year or two.

by Levon Yeganiantz  
Puerto Rico Traffic Safety Commission; San Juan, P.R.; Appu Kuttan and Assoc. 1374 Ashford Ave., Santurce, P.R. 00907  
Contract DOT-HS-160-2-251  
Rept. No. AKA-LY-75-1-V; 1975; 136p 20refs  
See also HS-802 385--HS-802 388.  
Availability: NTIS

HS-802 392

# **PUBLIC HEARING ON FMVSS [FEDERAL MOTOR VEHICLE SAFETY STANDARD] 208. TRANSCRIPT OF PROCEEDINGS, WASHINGTON, D.C.,**

### WEDNESDAY, 27 APRIL 1977 [OCCUPANT PROTECTION SYSTEMS]

A transcript of proceedings (first of two days) of a public hearing on FMVSS (Federal Motor Vehicle Safety Standard) 208, which requires automobile manufacturers to install some form of occupant protection system in their vehicles, is presented. The hearing was presided over by Secretary Brock Adams of the Department of Transportation. Participants in the hearing included representatives from insurance companies, research organizations, automobile companies, motor vehicle associations, consumer protection associations, individuals who have been involved in automobile accidents, and physicians.

National Hwy. Traffic Safety Administration, Washington, D.C. 20590  
1977; 321p refs  
See also HS-802 393.  
Availability: Ace-Federal Reporters, Inc., 444 North Capitol St., Washington, D.C. 20001

Secretary Brock Adams of the Department of Transportation. Participants in the hearing included representatives from insurance companies, research organizations, automobile companies, motor vehicle associations, consumer protection associations, individuals who have been involved in automobile accidents, and physicians.

National Hwy. Traffic Safety Administration  
1977; 166p  
See also HS-802 392.  
Availability: Ace-Federal Reporters, Inc., 444 North Capitol St., Washington, D.C. 20001

HS-802 394

### EVALUATION OF TEST DUMMY'S FLESH PARTS PRODUCED WITH SUBSTITUTE FOAMING COMPOUNDS. FIRST PROGRESS REPORT

Results to date are given for a research effort undertaken to determine whether differences exist between Part 572 anthropomorphic dummy component exterior surfaces molded of Nitrospan and those molded of alternate materials designated as Compound A and Compound B. The following tasks are to be performed in this study: determine the weight and external dimensions of selected segments, measure the component static and dynamic performance in accordance with test procedures specified in 49 CFR-Part 572, and measure whole dummy performance based on replicate accelerator sled tests performed in three test configurations. (This type of dummy is used by the National Highway Traffic Safety Administration (NHTSA) to test compliance with Federal Motor Vehicle

Safety Standard 208.) Because of the nature of the assembly of dummy components molded of Compounds A and B and the unknown weights of embedded components, it was not possible to determine precise weight differences attributable to the type of foam material. Calibration tests are approximately 50% complete at this time. The dual-seat sled test buck has been installed and is currently road for configuration 1 (belt restraint) testing.

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-6-01514  
Rept. No. ZM-6015-V; 1977; 15p 2refs  
Rept. for 1-31 Mar 1977. Second Progress Report is HS-802 395.  
Availability: Reference copy only

HS-802 395

### EVALUATION OF TEST DUMMY'S FLESH PARTS PRODUCED WITH SUBSTITUTE FOAMING COMPOUNDS. SECOND PROGRESS REPORT

Results to date are provided for component tests which were performed on part 572 anthropomorphic dummy exterior surfaces to determine whether differences exist between parts molded of nitrospan and those molded with alternate foaming materials designated as compound A and compound B. The following tasks are to be performed in this study: determine the weight and external dimensions of selected segments, measure the component static and dynamic performance in accordance with test procedures specified in 49 CFR-Part 572, and measure whole dummy performance based on replicate accelerator sled tests performed in three test configurations. (This type of dummy is used by the National Highway Traffic Safety Administration (NHTSA) to test compliance with Federal Motor Vehicle Safety Standard 208.) On the basis of data obtained from part 572 tests of the nitrospan and compounds A and B skin components, it is concluded that the type of skin foam compound does not preclude conformance of any components to appropriate part 572 performance requirements. Furthermore, on the basis of statistical inference from sled test data, no consistent pattern of differences in means or variances is evident for comparable dummies equipped with nitrospan or substitute compound skins. Hence, with consideration of the limited sample size and the inherent measurement variability demonstrated herein, it is concluded that no differences in dummy dynamic performance directly attributable to the type of skin foam compound are suggested by the results of this investigation.

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-6-01514  
Rept. No. ZM-6015-V; 1977; 31p 3refs  
Rept. for 1-30 Apr 1977. First progress report is HS-802 394.  
Availability: Reference copy only

HS-802 396

### MOTOR VEHICLE BRAKE FLUID: WATER TOLERANCE AND VISCOSITY. VOL. 1. SUMMARY REPORT

by James G. Brown  
Automotive Res. Assoc., Inc., 5404 Bandera Rd., San Antonio, Tex. 78238  
Contract DOT-HS-00912  
1977; 25p  
For abstract see HS-802 397.

blown foams to replace the blown foams in finding Part 572 Dummy flesh components. The device used by the National Highway Traffic Safety Administration (NHTSA) to test compliance with Federal Motor Vehicle Safety Standard 208 is an anthropomorphic test dummy, described as the Part 572 Dummy. The work was intended to minimize changes in vinyl foam formulations employing Nitrosan as a foaming agent and to establish molding techniques adaptable to production facilities of dummy manufacturers. The work involved establishing a data base for Nitrosan-blown foams and conducting such physical tests as were necessary to establish substantial equivalence between Azobis-blown and Nitrosan-blown foams. After such equivalence was established, full sets of dummy segments were molded with the Azobis-blown foams and subjected to additional tests to determine that they corresponded reasonably with Nitrosan-blown foams. Azobis-blown dummy segments were produced which proved to be comparable to Nitrosan-blown samples. It was found that only minor variations in formulations were required for the substitute material, and it was also found that only minor variations in molding techniques were necessary. Further work is recommended for some simplification of molding techniques, and additional specifications are recommended for skin thickness on dummy segments, average foam densities for the various segments, and uniformity of densities within each segment.

by Samuel W. Alderson; Steven J. Goldner  
Humanoid Systems, 747 East 223rd St., Carson, Calif. 90745  
Contract DOT-HS-6-01325  
1977; 51p  
Availability: NTIS

HS-802 399

#### **MOTORCYCLE SAFETY IMPROVEMENT. VOL. 1. SUMMARY REPORT. FINAL REPORT**

by A. Khadilkar; R. Nichols; R. Schwarz  
AMF Advanced Systems Lab., 495 South Fairview Ave.,  
Goleta, Calif. 93017  
Contract DOT-HS-5-01181  
1977; 22p  
For abstract see HS-802 400.  
Availability: NTIS

HS-802 400

#### **MOTORCYCLE SAFETY IMPROVEMENT. VOL. 2. TECHNICAL REPORT**

Motorcycle control cable strength and reliability, cornering clearances, and fuel system integrity are investigated and performance specifications developed for implementation as standards, test procedures, and design practices. Tensile tests proved to be a valid method for assessing control cables. Written specifications could be promoted by presentation to cable manufacturers as a recommended standard, or translation into an SAE or an FMVSS standard. A specification for tests of installed motorcycle controls uses force loads applied to controls to verify that the control system can handle a minimum load

gests, however, that machines with more than 16 clearance are over-involved in accidents. Clearance warning devices are recommended for installation. A static test procedure was developed to simulate the actual cornering situation. Fuel system integrity investigations show that fuel tanks, mounting systems, and caps on production motorcycles are usually adequately designed to handle impact loads. Plastic after-market tanks generally have excellent impact properties when new. Fiberglass is an inferior material for exposed fuel tanks, unless a flexible safety liner is used. Fuel leakage from production systems does not appear to be a substantial hazard.

by A. Khadilkar; R. Nichols; R. Schwarz  
AMF Advanced Systems Lab., 495 So. Fairview Ave., Goleta,  
Calif. 93017  
Contract DOT-HS-5-01181  
1977; 29p 10refs  
Rept. for Jun 1975-Jul 1976. Vol. 3 is HS-802 401, Vol. 1 is  
HS-802 339.  
Availability: NTIS

HS-802 401

#### **MOTORCYCLE SAFETY IMPROVEMENT. VOL. 3. APPENDICES**

Appendices are compiled for a research and development project on motorcycle control cable strength and reliability, cornering clearances, and fuel system integrity. The first appendix, on control cable survey and test data, includes installation geometries and tensile test load/deflection curves. The second appendix, on fuel system test data, shows graphic results of ten test platform and tank acceleration drop tests, and ten pendulum acceleration traces pendulum tests. Recommended specifications, in the third appendix, concern fuel system crash performance and control cable tests. Longitudinal and lateral acceleration specifications are formulated to ensure integrity of the fuel system in frontal and lateral impacts. Motorcycles are mounted on fixed platforms for testing. Control cable standards are established based on tensile tests which evaluate the adequacy of cables in handling possible in-service maximum loads. The fourth appendix, computer program documentation, presents documentation materials for the "SPIATE," "JAMMER," and "SCRATCH" programs.

by A. Khadilkar; R. Nichols; R. Schwarz  
AMF Advanced Systems Lab., 495 So. Fairview Ave., Goleta,  
Calif. 93017  
Contract DOT-HS-5-01181  
1977; 143p  
Vol. 1 is HS-802 399; Vol. 2 is HS-802 400.  
Availability: NTIS

HS-802 403

#### **RESEARCH SAFETY VEHICLE (RSV). PHASE 3. FIRST STATUS REPORT**

A status report on Calspan's Research Safety Vehicle (RSV) project delineates results by tasks: approximately 10 categories of project accomplishments are outlined. A major Phase 3 pro-

ject objective, design resolution and completion, has involved refinements in structural/body design. A new upper load beam design permits spot welding of mating flanges. Changes are made in front rails and side structure. Tear webbing load limiters and pyrotechnic gas inflators are being developed for occupant seat belt restraint. The engine/driveline task is comprised of changes in engine mounts; half-shafts; and manual transmission shift and accelerator linkages. Phase 3 cars are designed with a diagonally split brake system. Steering suspension developments include manual rack and pinion steering gear; steering rack mounting; steering knuckle; front lower control arm; front suspension torsion bar; front suspension geometry; and rear springs. Several headlamp designs are being evaluated. Styling changes have been made on front end surface and headlamp openings. Vehicle width analysis has resulted in a 4" widening to provide more seating space, resulting in a 50 lb. weight increase. Widening will result in increased production time and an additional cost of about \$25,000. A static crush test is used to approximate load distribution of an actual car-to-car impact. Test data have been incorporated into the computer model. Most testing has been conducted on a modified Simca 1308. Attachments include work planned for the next reporting period; a list of meetings,

### 2 (RSV), PHASE 3.

Phase 3 of Calspan's Research focuses on financing, contracting, planning, materials supply, and arrangements have been defined to NHTSA for approval. Arrangements have supply of Simca parts and assembly fixtures for Phase 3 vehicle test articles and Phase 4 vehicle development and delivery of components for the ant system have been arranged. Although delays in materials delivery have been a chronic problem, alternative supplies and sources are available to maintain the original schedule. Final definition of the force limiter for the air belt restraint is deemed the major problem at present. The vehicle interior, including the steering column, will be the same for both air bag and air belt systems, including the passenger air bag restraint under development by Minicars. Structural design changes to incorporate the larger engine and reduce pitching during barrier impact are on schedule. Drawings for modifications to the Simca 1308 to provide the "mule" car are complete, and fabrication is under way. Styling changes have been made to accommodate increased length of the engine compartment and to reduce aerodynamic drag. Front and rear headlamps have been selected. External changes, for example the rear spoiler, cooling slots, and headlamp curves, are an-

ticipated depending on scheduled wind tunnel tests. A list of planned Phase 4 tasks is included.

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-7-01551

1977; 119p

Proj. ZN-6069-V-2. Rept. for 1 Mar-30 Apr 1977. First Status Report is HS-802 403.

Availability: Reference copy only

HS-802 406

### PROGRAM EVALUATION SUPPORT FOR THE MOTOR VEHICLE DIAGNOSTIC INSPECTION DEMONSTRATION PROJECTS. VOL. 2. COSTS AND BENEFITS. FINAL REPORT

Report is made on costs and benefits of the Motor Vehicle Diagnostic Inspection Program Demonstration Projects conducted by Alabama, Arizona, Puerto Rico, Tennessee, and Washington, D.C. from Spring 1975 through June 1976. Published data relevant to the program are reviewed and data submitted by the sites are examined in order to determine whether a national diagnostic inspection program would be cost effective in terms of public benefits exceeding program costs. Ten sections comprise the report: a cost and benefits summary; experimental design; safety benefits; emission benefits; fuel usage; vehicle repair cost; costs summary; cost of inspection; post-accident inspection data; and impact on repair industry. The demonstration project, sponsored by NHTSA, entailed \$17 million in grants and technical assistance to the five jurisdictions. Results indicate many tangible instances of actual cost savings, improved safety and fuel economy, and reduced emissions. Interested consumers appear to be prime beneficiaries of the program. Safety benefits appear substantial for participants, due to reduced failure rates in vehicle subsystems. Emissions benefits include a 6% cost savings for tune-ups and carburetor work; reduced HC and CO emissions rates; and a 5% improvement in fuel economy after tune-up. Data before and after tune-ups shows fuel economy of 4.7%. Potential cost benefits of diagnostic information to the consumer include lower repair bills, lower vehicle life-cycle cost, and higher resale value. Net cost savings achieved as a result of diagnostic inspection would be offset by the diagnostic center's operational cost, administrative cost, and profit, estimated at about \$14 per car.

by J. L. Duda  
Computer Sciences Corp., 6565 Arlington Blvd., Falls Church, Va. 22046

Contract DOT-HS-5-01036

1977; 339p

Rept. for Nov 1974-Jun 1976. Vol. 1 is HS-802 405; Vol. 3 is HS-802 407.

Availability: NTIS

HS-802 408

### HARDSHIP LICENSING

A number of states have enacted hardship licensing laws to ameliorate the harsh impact of a total deprivation of the driving privilege in cases of some or all such suspensions or revocations. Status of state laws in effect as of 1 Jan 1976 on hardship licensing is briefly summarized by state. The common denominator of various forms of hardship licensing is the restoration or continuation of a driving privilege, usually

proaches to hardship licensing, differing in terms of basic justification for license issuance. The most common, the hardship approach, justifies issuance of the license in avoidance of the hardship which would otherwise result; 24 of 38 states follow this approach, issuing restricted licenses for employment purposes only, for example. The second conceptual approach, used by 12 states, is restricted licensing, similar to the first except that no hardship is required for justification. Six states use the third concept, a professional driver approach, which automatically entitles professional drivers to restricted or unrestricted hardship licensing. The rehabilitation approach, used by 15 states, requires the driver to show some merit or comply with some condition such as treatment or educational program, in order to receive a hardship license. States have differing approaches to issuance of hardship licenses, kinds of license withdrawals which create eligibility, restrictions which are required or authorized on such licenses, and termination of such licenses. Immediate eligibility is allowed by 32 states. Twenty states issue hardship licenses through the department of motor vehicles, and the courts are also used. Standards for issuance sometimes incorporate public safety and welfare. Hardship licenses are usually revokable like standard licenses.

by John W. English  
National Com. on Uniform Traffic Laws and Ordinances  
Contract DOT-HS-5-01121  
Publ: Traffic Laws Commentary v6 n3 (May 1977)  
1977; 65p 32refs  
Availability: GPO

HS-802 410

#### **ON-BOARD VEHICLE SENSOR TECHNOLOGY. VOL. 1. SUMMARY REPORT**

by R. Heldt; H. Burke  
Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01178  
Rept. No. AVSD-0353-76-RR; 1977; 30p  
For abstract, See HS-802 485.  
Availability: NTIS

HS-802 411

#### **MULTIDISCIPLINARY ACCIDENT INVESTIGATION DATA FILE, EDITING MANUAL AND REFERENCE INFORMATION. VOL. 1. 1976 EDITING MANUAL**

Editing conventions are outlined for use in processing Multidisciplinary Accident Investigation reported case vehicles into a time-shared accident data bank. The editing manual includes an "Annotated Collision Performance and Injury Report" (CPIR) Revision 3 and Air Cushion Restraint System (ACRS) Supplement in the appendix. The text documents the editing procedure and interpretations of each question (variable) on the CPIR form and its supplements. Question interpretations are broken down into categories of CPIR questions; occupant supplement questions; CPIR supplement questions; damage analysis questions; and ACRS supplement questions. Sections are included on application of the occupant injury classification (OIC), and a dictionary of specific inju-

Contract D01-HS-3-01134  
Rept. No. UM-HSR1-76-8-1; 1977; 174p  
Rept. for 18 Apr 1975-17 Apr 1976. Vol. 2 is HS-802 412.  
Availability: NTIS

HS-802 412

#### **MULTIDISCIPLINARY ACCIDENT INVESTIGATION DATA FILE, EDITING MANUAL AND REFERENCE INFORMATION. VOL. 2. 1976 REFERENCE INFORMATION**

Reference information is outlined for use by data editors in processing Multidisciplinary Accident Investigation (MDAI) reported case vehicles into a time-shared accident data bank. Information is generally restricted to passenger vehicles and light trucks such as pickups and small vans. All model years and foreign vehicles for which information was available are included. Material is organized alphabetically by 23 descriptors. Vehicle manufacturer and model year are used where necessary to suffix a descriptor page heading. Reference information is presented on dimensions; body models (GM Canada); body structure; brake anti-lock systems; and dimensions (imports). An energy table (kinetic); make/model codes; occupant classification; and restraint system data are included. Other categories are seat backs; seat back angles; side door reinforcement beams; and state codes. Steering column angles and EA; and steering wheel codes and EA are referenced. Also categorized are term prefix and case numbers; telescoping unit; and tire information. Other information classifications are trailer hitch information; VIN summary; and windshield codes.

University of Michigan, Hwy. Safety Res. Inst., Ann Arbor, Mich. 48109  
Contract DOT-HS-5-01134  
Rept. No. UM-HSR1-75-8-2; 1977; 174p  
Rept. for 18 Apr 1975-17 Apr 1976. Vol. 1 is HS-802 411.  
Availability: NTIS

HS-802 415

#### **COMPARISON OF ACCIDENT DATA COLLECTED ON-SCENE WITH FOLLOW-ON DATA**

Report is made on a study to determine whether a technician, collecting data on a follow-on basis, could obtain data of sufficient quality to allow accurate simulation of accident events. A sample of 21 cases was investigated on-scene using a multidisciplinary methodology. After a predetermined delay, accidents were investigated a second time using a single technician, who attempted to collect the same data elements as the on-scene teams. On-scene investigation teams obtained photographic documentation for all 37 vehicles involved in the sample, and crush dimensions for 35 of the 37 vehicles. Follow-on technicians obtained photographic documentation and crush dimensions for 34 of the 37 vehicles. Some vehicles were partially repaired at the time of examination by follow-on technicians, only 21 of 37 interviews were completed, and fewer occupant contacts were made. On-scene teams were somewhat more accurate in assigning Collision Deformation Classifications (CDC's) and vehicle weights than follow-on technicians.

Discrepancies noted in vehicle measurements did not affect reconstruction results. Schematics submitted by on-scene teams and follow-on technicians were in relatively close agreement. Difficulties were noted in three of 42 examinations of reconstruction results within a case. In examining reconstruction results between cases, difficulties were noted for trajectory simulations in three cases, and damage simulations in three cases. In general, there was a relatively low level of discrepancy noted between on-scene trajectory-based estimates and follow-on damage-based estimates. The level of discrepancy between on-scene and follow-on methodologies was sufficiently small to verify the latter as a valid approach to analytical data collection. A summary of crash simulations is included in the appendix.

by Donald L. Hendricks  
Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221  
Contract DOT-HS-053-3-609  
Rept. No. ZQ-5668-V-3; 1977; 161p  
Rept. for Jan 1973-Jul 1976.  
Availability: NTIS

HS-802 419

## PEDESTRIAN MODEL PARAMETRIC STUDIES. VOL. 1

by David W. Twigg; James L. Tocher  
Boeing Computer Services, Inc., Energy Technology  
Applications, P.O. Box 24346, Seattle, Wash. 98124  
Contract DOT-HS-356-3-719  
1977; 46p 10refs  
For abstract, see Vol. 2, HS-802 420.  
Availability: NTIS

HS-802 420

## PEDESTRIAN MODEL PARAMETRIC STUDIES. VOL. 2

A system of computer programs has been developed to simulate the injuries suffered by a pedestrian struck by an automobile. The system provides a semiautomatic search for safer hood/grille/bumper configurations and stiffness. After the software system was developed, a sequence of three major optimizations, interspersed with modeling changes to improve the accuracy of the simulations, was performed. Results from the optimization series were used to help design full-scale impact tests using child and adult dummies. In turn, experimental measurements were used to improve the mathematical model of the impact simulator. Results of these studies have provided some insights into vehicle design parameters which produce safer vehicles. Pedestrian simulation is complex relative to crash simulations of a victim within a vehicle. A flexible spine may be required for better simulation. A simple geometric rule explaining the factors which determine the optimal hood shape for a particular pedestrian was not found. The principal design problem is avoidance of head impact. A hard surface with a large coefficient of friction may effect better head protection. Padding the hood, grille, or bumper does not seem to reduce body injury. Vehicle front-end stiffness and energy absorption capacity are more important factors affecting pedestrian injury severity than front end shape. Recommendations for further research suggest that the single most important aspect of computerized impact simulation is the proper model representation of the force-deflection and moment rotation behavior of real "materials" (muscle, metal, foam, etc.) in a dynamic environ-

ment. Therefore, a series of "standard" tests should be devised to provide a complete enough set of data to characterize mathematical model behavior. Appendices include a review of optimization methods for the automobile-pedestrian problem; vehicle model details; and computer plots from child dummy calibration simulations.

by David W. Twigg; James L. Tocher  
Boeing Computer Services, Inc., Energy Technology  
Applications, P.O. Box 24346, Seattle, Wash. 98124  
Contract DOT-HS-356-3-719  
Rept. No. BCS-G0845; 1977; 121p 10refs  
Rept. for Jun 1973-Aug 1976. Summary report is HS-802 419.  
Availability: NTIS

HS-802 421

## VEHICLE DESIGN OPTIMIZATION SYSTEM USER MANUAL. FINAL REPORT

The Vehicle Design Optimization System (VDOS) is a group of four computer programs used for coordinated study of hood design on pedestrian fatalities and injuries. The four programs are OPTREG (optimization and regression analysis), PROMETHEUS 2 (accident simulation), ENTRACT (an interface program between OPTREG and PROMETHEUS 2, which converts the parametric hood model utilized by OPTREG to the finite element hood required by PROMETHEUS 2), and PRMPIT (an interface program between PROMETHEUS 2 and OPTREG which combines the detailed accident simulation measurements into a single number called a pedestrian injury index, and also generates Stromberg-Carlson 4020 plots of the accident data). This manual outlines usage instructions for ENTRACT and PRMPIT, including data preparation instructions and examples of CDC 6600 KRONOS Interactive Timesharing control card sequences for execution of the programs. Abbreviated usage instructions for PROMETHEUS 2 and OPTREG are presented. A detailed description of file formats is included, as well as particular instructions for communication files. VDOS is also applicable to studies for determining effects of changes in optimal vehicle designs on simulated pedestrian injuries and fatalities.

by R. M. Southall; D. W. Twigg  
Boeing Computer Services, Inc., Energy Technology  
Applications, P.O. Box 24346, Seattle, Wash. 98124  
Contract DOT-HS-356-3-719  
Rept. No. BCS-G0815; 1977; 164p  
Rept. for Jun 1973-Aug 1976.  
Availability: NTIS

HS-802 422

## OPTREG - AN INTERACTIVE COMPUTER PROGRAM FOR OPTIMIZATION AND REGRESSION. FINAL REPORT

A user manual for the OPTREG computer program describes features, gives examples of uses, and provides KIT control card sets performing the various OPTREG options. OPTREG is a computer program which provides stepwise multiple regression analysis and optimization of a user defined function by the geometric simplex method. Both optimization and regression are performed interactively. This gives the user visibility and quick response, as well as a high degree of control over the optimization and regression procedures. Because of the fine control over the optimization algorithm which is available, OPTREG is particularly well suited to optimization

of a function which is expensive to evaluate. OPTREG is programmed in FORTRAN IV, and operates on the CDC 6600 under the Kronos Interactive Timesharing (KIT) operating system. The manual is arranged by system operating information, regression analysis, automatic optimization, and manual optimization. Appendices include the Nelder-Mead Simplex algorithm, the stepwise multiple regression analysis, and a list of error messages.

by Richard A. Erickson; Rose M. Southall; David W. Twigg; Yvonne Y. Wong  
Boeing Computer Services, Inc., Energy Technology Applications, P.O. Box 24346, Seattle, Wash. 98124  
Contract DOT-HS-356-3-719  
Rept. No. BCS-G0792; 1977; 140p 10refs  
Rept. for Jun 1973-Aug 1976.  
Availability: NTIS

HS-802 423

## PROMETHEUS 2 - A USER ORIENTED PROGRAM FOR HUMAN CRASH DYNAMICS. FINAL REPORT

The PROMETHEUS 2 computer program, developed from the Office of Naval Research PROMETHEUS program, is an efficient user-oriented crash analysis program with interactive features. PROMETHEUS 2 simulates a pedestrian being struck in the side by the front of an automobile with a mathematical model composed of eleven linked rigid segments. A nonlinear finite element model of the vehicle structure is incorporated which interacts realistically with the victim. It is also possible to model a passenger inside a vehicle in certain crash environments. Various restraint systems can be simulated, including seat belt, shoulder harness and strap hangers. PROMETHEUS 2 input aids include free field data input and an on-line data edit capability. Output provides user selected time-history and occupant configuration plots as well as abbreviated output lists for a rapid scan of results. The program operates on the CDC 6600 computer in either a batch or interactive mode. A post processor is available which generates hard copy plots (Gerber or Stromberg-Carlson 4020) of PROMETHEUS 2 data. The post processor can also generate 16 mm motion pictures of the simulated accident. The user manual is arranged by synopsis of program input, program operation, preparation of input data, and a sample problem. Appendices present a strategy for belt force computation; a description of model and development of dynamic equations, a differential equation solver, and a cushion model.

by David W. Twigg  
Boeing Computer Services, Inc., Energy Technology Applications, P.O. Box 24346, Seattle, Wash. 98124  
Contract DOT-HS-356-3-719  
Rept. No. BCS-G0802; 1977; 215p 12refs  
Rept. for Jun 1973-Aug 1976.  
Availability: NTIS

HS-802 424

## PSYCHOPHYSICAL TESTS FOR DWI [DRIVING WHILE INTOXICATED] ARREST. FINAL REPORT

An evaluation of currently-used psychophysical tests for determining alcohol impairment in DWI (driving while intoxicated) arrests, the development of more sensitive and reliable tests, and the standardization of test administration were undertaken. Criteria for the selection of sobriety tests and an initial list of potential tests were derived from field observations.

interviews with law enforcement officers, and from a literature review. Administration and scoring procedures were standardized during laboratory pilot studies of the tests. On the basis of these preliminary investigations, the following tests were chosen for an evaluation study: One-Leg Stand, Walk-and-Turn, Finger-to-Nose, Finger Count, Alcohol Gaze Nystagmus (AGN), Tracing, and alternate tests (Romberg Body Sway, Subtraction, Counting Backward, Letter Cancellation). Ten officers administered the six-test battery to 238 participants who were light, moderate and heavy drinkers. Placebo or alcohol treatments produced BAC's (blood alcohol concentrations) in the range from zero to 0.15%. The police officers scored the performance of each test on a 1-10 scale, and on the basis of the entire battery judged whether the person should be arrested or released. All of the six tests were found to be alcohol sensitive, and the officers made correct arrest/release decisions for 76% of the participants. However, the officers' scoring indicated that they had adopted a lower level of impairment as a decision criterion for arrest than would typically be applied in the field. This resulted in a high rate of false-arrest decisions. A second approach to an arrest/release classification of participants used a test-score criterion as determined by linear regression calculations: 83% of the classifications were correct, and neither false arrest nor false release decisions were unduly high. A reduced "best" test set was determined by stepwise discrimination analysis and includes examination of balance (One-Leg Stand), walking (Walk-and-Turn) and jerking nystagmus movement of the eyes (Alcohol Gaze Nystagmus). It is further recommended that a more appropriate legal BAC limit would be 0.08% rather than the current arbitrarily defined level of 0.10%.

by Marcelline Burns; Herbert Moskowitz  
Southern California Res. Inst., 2033 Pontius Ave., Los Angeles, Calif. 90025  
Contract DOT-HS-5-01242  
Rept. No. SCRI-TR77-2; 1977; 125p 78refs  
Rept. for 30 Jun 1975-28 Feb 1977.  
Availability: NTIS

HS-802 425

## A METHODOLOGY FOR ANALYZING GENERAL CATEGORICAL DATA WITH MISCLASSIFICATION ERRORS WITH AN APPLICATION IN STUDYING SEAT BELT EFFECTIVENESS. FINAL REPORT

A methodology for analyzing general categorical data with misclassification errors was developed and applied to the study of seatbelt effectiveness. The methodology assumes the availability of an original large sample based on a fallible classifier, and requires obtaining a small supplementary sample that is cross-classified by both the fallible and a "true" (usually more expensive) classifying device. For the study of belt effectiveness, the original sample was drawn from North Carolina accident reports for the first eight months of 1975. The "true" classification of a subsample of these occupants is assumed to be obtained through hospital reports for the injured occupants and telephone interviews for the noninjured. Estimates of injury risk and belt effectiveness based on the North Carolina police-reported data only, the supplementary (nonpolice) data only, and the combined police and supplementary data (applying the developed methodology) are presented. Due to the relatively small size of the supplementary data, only two levels of each control variable (age and sex of the driver, model year and type of car, vehicle damage severity (TAD), and accident type) were considered. The

results of the analysis suggest that lap belts alone substantially reduce the likelihood of injury and that lap and shoulder belts together further reduce this likelihood. However, it should be noted that the specific estimates presented are far from satisfactory, due to their large STD's (standard deviations). Also, due primarily to the large STD's, significant differences in belt effectiveness could not be detected between the two levels of any of the factors considered. The supplementary sample size was somewhat over 2,000 cases, but it is probable that a sample three or four times as large is necessary in order to test the two-sample methodology. The sources of supplementary information were not examined for validity. Also, the combined sample of drivers interviewed over the phone and those reported by participating hospitals was not totally representative of the overall population of North Carolina drivers involved in accidents. Because of these limitations, the data presented should best be regarded as a mechanism for demonstrating a new technique, rather than as a definitive estimate of safety belt effectiveness. Research is needed to incorporate smoothing models for the entries in the supplementary sample, based on relatively few parameters for the misclassification errors. Appendices contain the methodology used in the analysis, the supplementary data, accident report information and the report form, telephone interview format, and hospital report form.

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University of North Carolina, Hwy. Safety Res. Center,  
Chapel Hill, N.C. 27514  
Contract DOT-HS-4-00897  
1977; 72p 16refs  
Rept. for Jan 1975-Apr 1977.  
Availability: NTIS

HS-802 426

# **TRAFFIC SAFETY '76. A REPORT BY THE PRESIDENT OF THE ADMINISTRATION OF THE HIGHWAY SAFETY ACT OF 1966, AS AMENDED**

Part 1 concerns the National Highway Transportation Safety Administration (NHTSA) and contains chapters on the following items: present and future highway safety; highway safety program standards; data acquisition, analysis and reporting; safer drivers, safer pedestrians; safer vehicles; services that improve traffic safety; special programs; international cooperation; the consumer's advocate; research and how it is used; the advisory committees; and administration. Part 2 concerns the Federal Highway Administration (FHWA) and contains chapters on the following: highway safety within the FHWA; highway safety standards, federally coordinated research program (FCRP); other highway safety activities; and administration. Appendices contain statistical compilation, membership of the National Highway Traffic Safety Advisory Committee, funding tables, NHTSA and FHWA publications lists, current research grants and contracts, and litigation during calendar year 1976. New features of this report include brief descriptions of recent developments in bicyclist safety and traffic safety on the Indian reservations, as addressed in the Highway Safety Act of 1973, as well as incentive grants to those states which have significantly reduced the actual number of traffic fatalities and highway fatality rates.

National Hwy. Traffic Safety Administration, Washington,  
D.C. 20590  
1977; 195p  
Rept. for 1 Jan 1976-31 Dec 1976.  
Availability: GPO Stock No. 050-003-00269-1

HS-802 427

# **TRAFFIC SAFETY '76. A REPORT BY THE PRESIDENT ON THE ADMINISTRATION OF THE NATIONAL TRAFFIC AND MOTOR VEHICLE SAFETY ACT OF 1966, AS AMENDED, AND THE MOTOR VEHICLE INFORMATION AND COST SAVINGS ACT OF 1972, AS AMENDED BY THE ENERGY POLICY AND CONSERVATION ACT OF 1975**

Chapters of the report contain discussions of the following present and future motor vehicle safety; the Federal Vehicle Safety Standards (FMVSS); data acquisition, analysis and reporting; crash survivability; crash avoidance; star enforcement and defects investigation; litigation and administrative enforcement; special programs; the consumer's advocate; research and how it is used; National Motor Vehicle Safety Advisory Council; and administration. Appendices contain statistical compilation, membership of the National Vehicle Safety Advisory Council, funding tables, public lists of the National Highway Traffic Safety Administration current research grants and contracts, and litigation during calendar year 1976.

Nat'l Hwy. Traffic Safety Administration, Washington  
D.C. 20590  
1977; 158p  
Rept. for 1 Jan 1976-31 Dec 1976.  
Availability: GPO Stock No. 050-003-00268-2

HS-802 428

# **ACCIDENT INVOLVEMENT AND CRASH INJURY RATES BY MAKE, MODEL, AND YEAR OF CAR FINAL REPORT**

Estimates of annual mileages along with accident and injury rates have been computed for various vehicle make models in an investigation of the vehicle's role in the driving environment. The estimates were derived using the Carolina vehicle registration file, the North Carolina accident file, and a state-wide collection of motor vehicle inspection receipts representing the sample of registered vehicles inspected primarily during Oct 1974. The four accident involvement and injury rates (per million vehicle miles) considered were overall and single vehicle accident rates, driver and vehicle severity (most severe occupant injury). Finally, comparisons of accident and injury rates by vehicle size and body style (for standard-sized Chevrolet and full-sized cars) are presented. The annual mileage estimates showed a decrease with vehicle age for vehicle size groups at individual makes. Larger cars were found to have higher mileages than smaller cars. In comparing mileages for different body styles of standard-sized cars, the relatively new sedans had higher annual mileages than sedans and hardtops. All accident and injury rates declined for newer models. The decrease in accident involvement rates was pronounced for larger cars, injury rates declined for all vehicle sizes. In contrasting accident and injury rates for different vehicle sizes for comparable model years, for newer full-sized cars had the lowest accident and injury rates. Among standard-sized cars, hardtops had significantly higher accident and injury rates than either sedans or station wagons.



november 30, 1977

HS-802 431

In addition, two-door cars had higher involvement and injury rates than their four-door counterparts.

by Amitabh K. Dutt; Donald W. Reinhardt  
University of North Carolina, Hwy. Safety Res. Center,  
Chapel Hill, N.C. 27514  
Contract DOT-HS-4-00897  
1977; 173p 19refs  
Rept. for I Sep 1974-30 Apr 1977.  
Availability: NTIS

HS-802 429

#### FIGURE EIGHT FORMAT FOR DRIVER COLLISION RESPONSE DATA COLLECTION--FEASIBILITY STUDY. FINAL REPORT

A feasibility study of utilizing Figure Eight auto racing as a format to collect real-time driver collision response data was performed to address the following issues: the development of criteria to select drivers most likely to be involved in meaningful collisions, the determination of the frequency of occurrence of meaningful collisions, and potential predictive models. The study base was limited to persons associated with the Figure Eight Auto Racers Association, operating out of Ascot Park in Gardena, Calif. and other groups servicing the association and included the following: drivers, promoters, track and pit personnel, fans, and insurance carriers. The study was limited to the acquisition of information directly from Figure Eight participants and other personnel through a quasi-interview process involving discussion-guidelines which were constructed for each of the potential sample groups. A limited set of interviews conducted with members from each group indicated that information derived from all but the driver group was not central to meeting the objectives; therefore, it was decided to rely entirely upon information derived from the drivers. Based upon the results of interviews with drivers and more limited discussions with other groups, some conclusions were formulated consistent with the project objectives. Figure Eight auto racing offers the potential for real-time driver collision response data collection for a wide range of collision conditions and severities. Driver members of the Figure Eight Auto Racing Association cooperated fully in the feasibility study and would cooperate in a future experimental program. Collision occurrence is likely to be highest in the main event and in turn is highest in the first 25% of this event. A mix of inexperienced and experienced drivers is likely to be associated with increased collision probability. Figure Eight Auto Race drivers indicated that they make subjective judgments, based upon past performance, knowledge of the likely mechanical performance of other cars, and psychological factors, regarding the driver/car combination most likely to be involved in intersection collisions. No objective criterion could be developed to predict intersection collision involvement with certainty. Due to the relatively low probability of intersection collisions, attempts to verify the subjective selection criterion were not successful within the validation period available (three weekends of racing). It is recommended that additional verification be sought when the racing season recommences.

by J. M. Zueiback; G. R. Hatterick  
Science Applications, Inc., 101 Continental Bldg., Suite 301,  
El Segundo, Calif. 90245  
Contract NHTSA-6-5905  
Rept. No. SA1-260-77-542; 1977; 93p  
Rept. for Aug-Dec 1976.  
Availability: NTIS

HS-802 430

#### FATAL ACCIDENT REPORTING SYSTEM. REPORT FOR THE FIRST NINE MONTHS OF 1976

Information collected in the Fatal Accident Reporting System (FARS) computerized data base on fatal motor vehicle traffic accidents occurring during the first nine months of 1976 in the 50 states, the District of Columbia, and Puerto Rico is presented in tabular and graphical form. The following sources are utilized for FARS information: police accident reports, driver license files, motor vehicle registration files, Vital Statistics and State Highway Department records. These sources are occasionally supplemented by Emergency Medical Service reports and hospital records. Each accident in FARS contains at least one fatality and has occurred on a trafficway. The FARS definition of a fatality is one which occurs within 30 days of a motor vehicle traffic accident and as a result of the accident. Based on projections made by the National Highway Traffic Safety Administration (NHTSA) from fatalities reported monthly by the states, the national file is estimated to be 98% complete; since there is some variation in completeness among individual states, caution must be exercised when interpreting state data. When interpreting the data, it must be kept in mind that statistics obtained from the data often summarize complex relationships into a small set of numbers, resulting in a loss of information. The tabular data include the following: fatalities by state and month, accidents by state and land use, accidents by state and class trafficway, occupant and nonoccupant fatalities by state of accident, first harmful event (noncollision accidents, collisions with nonfixed object, collisions with fixed object) by state of accident, accidents and fatalities by state for the first nine months of 1975 and 1976, accidents and fatalities by month for the first nine months of 1975 and 1976, fatalities by person type (driver, passenger, nonoccupant) by month for the first nine months of 1975 and 1976, and fatalities by type vehicle (automobiles, motorcycles, pick-ups/vans, trucks) occupied for the first nine months of 1975 and 1976.

National Hwy. Traffic Safety Administration, National Center  
for Statistics and Analysis, Washington, D.C. 20590  
1977; 33p  
Availability: NTIS

HS-802 431

#### CAR-TO-CAR SIDE IMPACT CRASH AND CRASH TESTING (TASK 3) TEST REPORT. TEST: 1. TYPE OF TEST: CAR-TO-CAR, FRONT-TO-SIDE, 60° ANGLE

Results of car-to-car, front-to-side, 60° angle crash testing are presented. The objectives of this test are as follows: to determine the loads in the structures of an impacted vehicle and the impacting vehicle for side impact loading conditions, to compare the failure modes of a vehicle induced by static and dynamic side testing, and to provide data for the development of a side impact variable rigidity barrier. A secondary objective was to compare the following two independent methods of obtaining dynamic intrusion measurements: mechanical displacement devices each employing three rotary potentiometers to monitor two angles and a length; and a photogrammetric technique developed by Chrysler Corporation which employs a calibrated, high-speed motion picture camera. Included are the still photographs, the electronic data in plotted form for the accelerometers and the mechanical displacement-measuring

devices, accelerometer location identification, and summaries of the simulated occupant data from the bullet vehicle (1975 Ford Torino). The target vehicle (1975 Plymouth Fury) had the seats removed to permit installation of the displacement-measuring devices. Severe intrusion was experienced in the target vehicle as a result of the B-pillar lower end separating from the sill. A simple static crush test of the bench seat was conducted to evaluate the possible effects of the front bench seat removal. It was concluded that the seat could have a significant effect on the side impact performance of the vehicle. The data obtained by the two independent methods appear to be satisfactory for the most part with reasonable agreement between the displacement devices and the photographic technique. Both film and mechanical measurements indicate a maximum intrusion of 23 to 25 inches.

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-5-01099  
1976; 183p  
Availability: Reference copy only

HS-802 432

**CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH TESTING (TASK 3) TEST REPORT. TESTS: CRASH TEST NO. 2, CAR-TO-CAR FRONT TO SIDE[ 60° ANGLE, DECEMBER 9, 1976; STATIC CRUSH TEST OF 1975 PLYMOUTH FURY SEAT[ SIDE CRUSH OF SEAT ONLY AS INSTALLED IN VEHICLE, DECEMBER 14, 1976**

Car-to-car crush and crash testing was conducted to investigate the structural contribution of the 1975 Plymouth Fury target vehicle seat in a side impact, in order to determine the loads in the structures of an impacted vehicle and the impacting vehicle for side impact loading conditions, to compare the failure modes of a vehicle induced by static and dynamic side testing, and to provide data for the development of a side impact variable rigidity barrier. The first test conducted was a car-to-car, front to side, 60° angle crash test. In comparison with a previous test which was conducted without a seat installed in the target car and which resulted in extensive intrusion because of the "B" pillar separation from the lower sill, this test resulted in significantly more damage to the bullet Torino and a reduction of approximately 10 inches in the maximum value of intrusion for the target Fury. The second test conducted was a static crush test of the seat installed in the chassis of the target Fury, but with the doors removed on the driver side. Results of this test indicate that the seat is capable of sustaining approximately 7,000 pounds of force. Included are still photographs of the test vehicle before and after impact, the electronic data in graph form, a vehicle damage sketch for the target Fury, tabulated pretest and posttest vehicle dimensions, instrumentation location and identification, and summaries of the simulated occupant data including injury criteria values. In addition, a comparison of electronic data from the previous crash test of a Fury without a seat and from the crash study presented herein with a seat installed is presented in graph form.

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-5-01099  
1977; 128p  
Availability: Reference copy only

HS-802 433

**CAR-TO-SIDE IMPACT CRUSH AND CRASH TESTING (TASK 3) STATIC CRUSH TEST REI TESTS: 1. 1975 FORD TORINO FRONT-TO-AN 1975 PLYMOUTH FURY SIDE, 2. 1975 FORD T FRONT-TO-ANGLED BARRIER, 3. SAE CONTOURED BARRIER-TO-ANGLED 1975 PLYMOUTH FURY SIDE**

Three static crush tests using a 1975 Ford Torino an Plymouth Fury were conducted. For the first test, th front end was pushed into the angled Fury side. Th test used a 1975 Ford Torino front end against an angl er. The third test employed an SAE contoured barrier another angled Fury side. Crush test load data, s photographs of the crushing, and sketches defining th geometry for each test are presented. An event log c pertinent comments concerning various observation during the crushing sequence is also included for each

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-5-01099  
1976; 113p  
Availability: Reference copy only

HS-802 435

**PASSENGER CAR SPECIFICATIONS**

Passenger car specifications for American-made cars years 1966 through 1976, are presented in tabular f year. Curb weight, wheelbase, overall length, overall and overall height are provided for the various models domestic and foreign manufacturers.

Motor Vehicle Mfrs. Assoc., Engineering Res. Dept.  
1977; 36p  
Data extracted from March issues of Automotive Indus Reprinted by the National Hwy. Traffic Safety Admini Washington, D.C. 20590 with permission of the Chilton Availability: NTIS

HS-802 436

**SAFETY RELATED RECALL CAMPAIGNS FOI MOTOR VEHICLES AND MOTOR VEHICLE EQUIPMENT[ INCLUDING TIRES--DETAILED REPORTS FROM OCTOBER 1, 1976 TO DECEMBER 31, 1976. QUARTERLY REPORT**

Correspondence is presented concerning defect reca paigns conducted by domestic and foreign motor motor vehicle equipment, and tire manufacturers du quarter 1 Oct-31 Dec 76. The domestic motor vehicle m turers include the following: AM General Corp.; Apollo Homes; Argosy Manufacturing Co.; Blue Bird Coach Brownlow Manufacturing Co.; Cobra Industries, Inc. calibur Automobile Corp.; Fleetwood Enterprises, Inc.; Co.; Ford Motor Co.; Fortin Welding and Manufacturin Freightliner Corp.; Fruehauf Corp.; General Motors Grumman Allied Industries, Inc.; John Evans Manuf. Co., Inc.; Mack Trucks, Inc.; Midland-Ross Corp.; Inc.; Pat-Car Corp.; Somerset Marine; Trailite, Inc.; and Motor Corp. Foreign motor vehicle manufacturers incl following: Batavus, USA, Inc.; Bayerische Motoren Fiat Distributors, Inc.; Mercedes-Benz of North A

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Inc.; Prevost Car, Inc.; Saab-Scania of America, Inc.; Vespa of America Corp.; and Volkswagen of America, Inc. Motor vehicle equipment manufacturers include the following: Air-O-Matic Power; DPD Manufacturing Co., Inc.; Firestone Steel Products Co.; Kelsey-Hayes Co.; Perris Valley Campers; Rockwell International; Wagner Electric Corp.; and Wheel Specialties Co. Tire manufacturers include the following: Armstrong Tire Co.; Atlas Supply Co.; Ceat Pneumatic; Cooper Tire and Rubber Co.; Dayton Tire and Rubber Co.; Dunlop Tire and Rubber Corp.; Firestone Tire and Rubber Co.; General Tire and Rubber Co.; and Goodyear Tire and Rubber Co.

National Hwy. Traffic Safety Administration, Washington, D.C. 20590  
1977; 808p  
Availability: NTIS

HS-802 437

# **COURSE GUIDE. NATIONAL TRAINING COURSE: EMERGENCY MEDICAL TECHNICIAN, PARAMEDIC**

A course guide for training emergency medical technicians (EMT)-paramedics meets national standards; it is based on recommendations of the Task Force on Emergency Medical Technicians of the National Academy of Sciences/National Research Council (NAS/NRC). Interim materials were developed by the Springfield Medical Center (Mass.) and from experiences derived from advanced emergency care systems across the country. The comprehensive curriculum consists of the following three components: didactic, clinical (in-hospital), and field internship. The course guide contains a description of the training program; suggestions for course planning, including class size, scheduling of classes, recommended facilities, training aids, and instructor and student prerequisites; guidelines for conducting the course; recommendations for student evaluation; and suggestions for continuing education programs. In addition, a procedure for the planning and implementation of this paramedic program is suggested. Finally, the course guide is a statement of policy that sets forth minimum standards for developing the structure and quality of paramedic training programs and that can serve as a basis for certification or accreditation. The program is designed to be presented either in its entirety or in segments, depending on local needs and resources. The student who successfully completes the entire program will have met the criteria established by the NAS/NRC task force as an EMT-paramedic.

National Hwy. Traffic Safety Administration, Washington, D.C. 20590  
1977; 92p  
Availability: GPO

HS-802 472

# **COLLECTION OF POST-ASAP DATA AND PREPARATION OF ANALYTIC STUDIES FOR THE OREGON ASAP [ALCOHOL SAFETY ACTION PROJECT]. FINAL REPORT**

An evaluation of Portland, Oregon's ASAP (Alcohol Safety Action Project) is based on collection of post-ASAP data, analysis of ultimate performance measures to determine total project impact, and an analysis of rehabilitation/treatment pro-

grams. No overall reduction in fatal crashes was found to have occurred during the period in which the ASAP was in operation. Injury crashes went down and stayed down through the first two years of the post-ASAP period. Special ASAP enforcement patrols of the first half of 1975 were less effective in increasing the arrest level for drunk driving. BAC (blood alcohol concentration) levels of arrested drivers remained lower in 1975 than in the pre-ASAP period. Conviction levels of court cases in 1975 were better than those during mid-ASAP years. BAC levels of alcohol-related fatal crashes did not change during the ASAP period. Fatal crashes during high drinking/driving hours remained steady during the ASAP years. BAC levels of fatally injured drivers were unchanged, as well as characteristics of fatally injured drivers. Fatally injured drivers are generally different from DUI (driving under the influence) drivers. Times of fatal crashes and drunk-driving arrests are different; the middle of the day was consistently overrepresented for the fatal crash events. Relationships between arrest activity and key evaluation measures (mean BAC's of fatally injured drivers, number of single vehicle fatal crashes, number of multivehicle fatal crashes, number of pedestrian fatal crashes, total number of fatal crashes, number of injury accidents, number of arrests) were generally weak and quite variable. No treatment modality (Antabuse only, therapy only, Antabuse and therapy, Alcoholics Anonymous) was appreciably better than the others nor its own no-treatment control condition. Treatment/rehabilitation effectiveness, it is recommended, should be assessed by additional measures beyond DUI recidivism only. Finally, the court system response to accessible diagnostic/treatment services continues as a program strength.

by Noel Kaestner  
Contract DOT-HS-5-01186  
Rept. No. NHTSA-6-6216; 1977; 155p  
Rept. for 1 Oct 1975-1 Sep 1976.  
Availability: NTIS

HS-802 473

# **TRI-LEVEL ACCIDENT RESEARCH STUDY. FINAL REPORT NEW YORK STATE ROADWAYS**

A three-level accident research study was made of roadways in an eight-county area of western New York State known as the Niagara Frontier, with particular emphasis on data collection. Information is available for 34,988 accidents. Comparison is made of restraint use and injuries among male and female drivers in automobile frontal impacts. Restraint use and accident severity were quite similar for both males and females; also, there was little difference in injury distribution when restraints were not used. Use of restraints caused a marked decrease in windshield-caused head injuries to drivers of both genders. Use of the lap belt increased contact with nearer objects while decreasing contact with objects further away; which objects were contacted depended on size of the occupant. Use of lap belt had relatively little influence on thorax injuries caused by the steering wheel. The crash environment for recent model cars was studied in terms of specific accident circumstances such as object struck, area of impact, or direction of force (data from three levels of tri-level program as well as National Safety Council data). NSC data show that two-vehicle accidents are more frequent and result in more fatal accidents than other types; second in rank is the single-vehicle noncollision accident. Police injury ratings cannot discriminate among injury levels. The more serious injuries involved more single car accidents, more frontal impacts, less

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rear impacts, more right front occupants and fewer drivers, much more occupant ejection, less use of restraints, and more drivers who had been drinking, ill, or who fell asleep. Two-car accidents involving severe injuries, compared with single-vehicle accidents, involved more left front impacts, larger impact areas, more rear impacts, and fewer severe injuries. The data selection process influences the results. The development of the Calspan Reconstruction of Accident Speeds on the Highway (CRASH) computer program is presented. Its closed-form calculation procedure, which was initially developed as a starting routine for the SMAC computer program, has been shown to be capable of yielding impact velocity approximations with a plus or minus 12% accuracy. The operating cost ranges from only \$1.00 to \$5.00 per case, depending on the extent of the available case data. Procedures for evaluating CRASH are reviewed.

by John W. Garrett; Raymond R. McHenry; Donald L. Hendricks; Kenneth Perchonok  
Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221  
Contract DOT-HS-053-3-609  
Rept. No. CC-ZQ-5668-V-2; 1977; 133p 32refs  
Rept. for 1 Jan-31 Dec 1975.  
Availability: NTIS

HS-802 474

#### CAUSATIVE FACTORS AND COUNTERMEASURES FOR RURAL AND SUBURBAN PEDESTRIAN ACCIDENTS: ACCIDENT DATA COLLECTION AND ANALYSIS-APPENDICES

Appendices to a report concerning the collection and analysis of data on rural and suburban pedestrian accidents and the identification of potential countermeasures are presented. Data on a stratified sample of over 1,500 rural and suburban accidents from six states (California, Michigan, Missouri, North Carolina, Pennsylvania, Texas) were collected during interviews and on-site observations. These data included behavioral sequence items, site characteristics items, and exposure data items directed at identifying the precipitating and predisposing causal factors in each accident. The data analysis emphasized the development of characteristic accident situations or "accident types" from groups of behaviorally similar accidents. The appendices presented herein include the following information: data collection form, field investigator coding manual, printout distribution of data items, pedestrian and driver precipitating factors for each accident type, abbreviated accident descriptions for selected accident types, and operation forms.

by Richard L. Knoblauch; Wilson Moore, Jr.; Peter R. Schmitz; Barbara J. Sommers  
Biotechnology, Inc., 3027 Rosemary Lane, Falls Church, Va. 22042  
Contract DOT-HS-355-3-718  
1977; 336p  
Rept. for Jul 1973-Mar 1976, phases 1 and 2.  
Availability: NTIS

HS-802 475

#### ESTIMATING THE SAFETY EFFECTS OF THE 55 MPH NATIONAL SPEED LIMIT

Regression lines were established for the fatality rate on each of the major highway systems to compute the expected values of the fatality rates for 1974 and 1975. The expected number

of fatalities on each system was computed by applying the rates to the reported amount of travel. The difference between the expected number of fatalities and the actual number represents the reduction attributed to the speed limit. The reported number of highway fatalities for each of the years 1974 and 1975 were about 9,000 fatalities below the 1973 total, approximately 3,000 of the 9,000 reduction is attributed to ported changes in travel and to the effect of continuous safety improvements. The remaining reduction of about 6,000 fatalities per year represents an estimate of the reduction which is due to variations in travel patterns and historical safety trends inasmuch as their contribution has already been accounted in the previous estimate of 3,000 fatalities. It is known that establishment of the speed limit resulted in a significant lowering of travel speeds on the highways in both years. This reduction in speed appears to be the only special change that taken place and can also be measured. It is quite possible that other changes have taken place and contributed to this preciable savings of lives, but such changes have never been identified. It would, therefore, be reasonable at this time to conclude that about 6,000 fatalities per year have been saved since the enactment of the 55 mph speed limit.

by Ezio Cerrelli  
National Hwy. Traffic Safety Administration, Mathematical Analysis Div., Washington, D.C. 20590  
1977; 66p  
Availability: NHTSA

HS-802 480

#### SEAT BELT PERFORMANCE IN 30 MPH BARRIER IMPACTS

A summary of test data relating to the seat belt performance of nine model year 1976 automobiles when subjected to FMVSS (Federal Motor Vehicle Safety Standard) No. 208 Fuel System Integrity-Passenger Cars, is presented, and results of this testing are discussed. Compliance with FMVSS No. 301 is determined by subjecting a vehicle to a 30 mph barrier impact, the vehicle containing two part No. 572 test dummies. Seat belt, test dummy, and vehicle structural data were collected on each test. Seat belt data consists of both lap and torso belt forces. The dummy data consists of longitudinal, lateral and vertical head and chest acceleration measurements. From these data, resultant head and chest accelerations were obtained as well as the head injury criteria (HIC) and severity index (CSI). The vehicle structural data includes vehicle weight, vehicle overall static crush, steering column collapse, and vehicle deceleration at three points in the occupant compartment. Dynamic crush was calculated from the vehicle accelerometer records. The data were analyzed in an attempt to determine the relationship, if any, between observed measurements and such parameters as vehicle weight, dynamic crush, and survival distance. It was determined that parameters such as vehicle weight and survival distance are not necessarily satisfactory indicators of seat belt performance. A correlation appears to exist between upper torso belt load and occupant/vehicle "ride-down" duration. In those vehicles which exhibit a short crash duration and excessive slack time, upper torso belt forces are severe. It is recommended that ride-down slack time be considered as a means for improving seat belt performance if vehicle crush cannot be increased. Finally, it is concluded that since head contact with the steering wheel occurred in every test, the implication of this problem must be assessed in terms of seat belt performance, and that steering

column behavior during the crash event must be made comparable with the kinematics of the restrained occupant.

by John B. Morris  
National Hwy. Traffic Safety Administration, Office of  
Vehicle Systems Res., 2100 Second St., S.W., Washington,  
D.C. 20590  
1977; 65p 12refs  
Testing performed by Dynamic Science, Inc., 1850 West  
Pinnacle Peak Rd., Phoenix, Ariz. 85027.  
Availability: NTIS

HS-802 484

#### **EVALUATION OF TEST DUMMY'S FLESH PARTS PRODUCED WITH SUBSTITUTE FOAMING COMPOUNDS. THIRD AND FOURTH PROGRESS REPORT, PERIOD 1 MAY TO 17 JUNE 1977**

A series of experimental studies was conducted to determine whether differences exist between Part 572 anthropomorphic dummy component exterior surfaces molded of Nitrosan and surfaces molded of alternate foaming materials designated as Compound A and Compound B. Belt sled tests, air bag sled tests, and steering column sled tests were performed. First, head injury criteria (HIC) numbers were computed using head acceleration measurements obtained from replicate sled tests of each dummy flesh configuration. Statistical analyses of the HIC numbers showed no differences in the means or variances for the different foam materials. In addition to obtaining HIC numbers, the variability in air bag configuration head acceleration data observed in earlier testing was examined in relation to the run-to-run variation in the pre-test volume of the meteorological balloon which lines the air bag. A procedure was developed to both pre-condition and screen the liners prior to use in sled testing. A tendency toward improved head acceleration repeatability was noted with this procedure; however, a full assessment of the extent of improvement awaits further analysis of test data. In a second phase of testing, the newly developed procedure for the selection of meteorological balloons used as air bag liners in the air bag restraint system was applied to reduce the variability of this configuration which is believed to be a cause of the unusual head acceleration measurement variability seen in earlier tests. With consideration of the inherent measurement variability which is characteristic of complex impact test environments, the results of statistical analyses of test data performed thus far fail to show any systematic difference in dummy dynamic performance which can be attributed to the type of skin foam compound. Also in this phase of testing, head drop impact tests of the four dummy heads and pendulum tests of the four head/neck assemblies were performed in accordance with Part 572 procedures (heads composed of a single vinyl compound, not foam material); and all four heads were found to conform to applicable Part 572 criteria.

Calspan Corp., Buffalo, N.Y. 14221  
Contract DOT-HS-6-01514  
1977; 47p 1ref  
Availability: Reference copy only

HS-802 485

#### **ON-BOARD VEHICLE SENSOR TECHNOLOGY. VOL. 2: TECHNICAL REPORT**

As part of the National Highway Traffic Safety Administration's (NHTSA) On-Board Vehicle Sensory Technology Program, 43 areas were identified in the brake, steering, suspension, tire, lighting and signalling systems where safety or inspection benefits might be obtained through the application of on-board vehicle sensors utilizing either on-board or off-board readout. These areas were screened against a variety of criteria: Can the safety benefit be documented in accident records? Does component degradation significantly affect limit performance? Does component failure create an immediate safety hazard? Does the component fail frequently? Does sensing of the component offer a consumer benefit? Is it practical to provide real time readout to the driver? Will the safety benefit of sensing be significant relative to PMVI (periodic motor vehicle inspection)? Is off-board readout possible? Would the on-board sensor provide a superior inspection? Would the on-board sensor and associated readout devices cost significantly more than present inspection techniques? The most important criterion was the potential for accident reduction as determined in the Indiana Tri-Level Studies in Accident Causation data base. Eleven areas were judged to warrant detailed evaluation of implementation considerations, and these candidate areas (brake performance, tire inflation, brake light intensity, tire tread depth, steering wheel play, brake light electrical system, brake friction material wear, brake fluid leak, shock absorber, tire integrity, front end alignment) were then subjected to further analysis which included identification of the following: currently available hardware, existing techniques for sensor application, conceptual devices where hardware does not now exist, and improvements possible in existing devices. In addition, a cost-benefit analysis was performed for each candidate area, utilizing estimates of sensor life-cycle cost and benefit, including both safety and other impacts. The results presented are preliminary in nature, due to the weakness of data bases in all important areas. Limited consideration was also given to alternative countermeasures in each area. Four candidate areas are judged to offer the potential of a favorable benefit/cost ratio: brake performance, tire tread depth, brake lights and brake friction material.

by R. Heldt; H. Burke  
Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01178  
Rept. No. AVSD-0353-76-RR; 1977; 306p 282refs  
Rept. for Jun 1975-Dec 1976.  
Availability: NTIS

HS-802 486

#### **TRUCK AND BUS SAFETY SUBCOMMITTEE [NATIONAL HIGHWAY SAFETY ADVISORY COMMITTEE]. TRANSCRIPT OF PROCEEDINGS, WASHINGTON, D.C., THURSDAY, 19 MAY 1977**

A transcript of the proceedings of the third and final general hearing of the Truck and Bus Safety Subcommittee of the National Highway Safety Advisory Committee on the subject of FMVSS (Federal Motor Vehicle Safety Standard) 121 is presented. FMVSS 121 concerns braking systems on tractors and trailers; the hearing is related to the intermix of pre-121 and post-121 vehicles and operating those vehicles, the tractor with 121 and a trailer without, and vice versa. Representatives from the trucking industry, manufacturers of commercial vehi-

the inspection and counseling areas; difficulties in obtaining adequate quantities of motorist repair, maintenance, and fuel consumption records; failure to implement strong quality assurance measures in the inspection process and in the acquisition and transmittal of inspection data; and difficulties in recruiting (and retaining) motorists for participation in the program. Despite these and other deficiencies, the quality of operations actually achieved probably represents a realistic optimum for the inspection community. Some additional findings and achievements include the following: operation of the projects found to have no significant impact on the calibration and maintenance practices of the repair industry; performance of inspection and test equipment found to be inadequate for implementing established inspection criteria; development of a methodology for evaluating direct measures of project performance with regard to saving money for the motorist; development of a methodology for evaluating inspection standards and application of methodology to 11 categories of inspection items; accessibility and complexity found to be the most frequently noted vehicle design characteristics that facilitate or hinder inspection and repair; development of facility designs to accommodate a set of inspection tasks common to the five projects; projects found to perform reasonably well with respect to the frequency of correct inspection verdicts (near 90%); latitude permitted by NHTSA guidelines found to result in considerable differences among projects in many operations; and few instances of incompatibility found between inspection equipment and vehicles.

by Kenneth P. Joncas, et al  
Avco Corp., Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01037  
Rept. No. AVSD-0022-77-RR; 1977; 98p 3refs  
Rept. for Nov 1974-Dec 1976. See also HS-802 489, HS-802 491--HS-802 493, HS-802 496, HS-802 497.  
Availability: NTIS

HS-802 491

# **DIAGNOSTIC MOTOR VEHICLE INSPECTION DEMONSTRATION PROJECTS, PROGRAM ENGINEERING SUPPORT. VOL. 2--APPENDIX A**

Evaluation is made of the measurement performance of inspection equipment used in the conduct of the Motor Vehicle Diagnostic Inspection Demonstration Program operated under Title III of the Motor Vehicle Information and Cost Savings Act (PL 92-513). The inspection equipment included alignment analyzers, brake performance testers, headlamp aim testers, hand tools and gauges, engine analyzers, scuff gauges, and exhaust analyzers. With regard to the inspection equipment at the regional sites, the following conclusions were reached: performance of equipment found to be inadequate for implementing the established inspection criteria when judged on the basis of comparison with an engineering tolerance established for that purpose; alignment analyzers found not to demonstrate performance within the accuracy considered necessary for proper application of the established inspection limits; best repeatability in alignment measurements found in camber measurements, worst in caster; brake performance testers found not to demonstrate acceptable performance (the high-constant-speed roller type of tester ranking highest in performance); repeatability measurements on three types of brake performance testers not definitive; headlamp aim measurements unsatisfactory in terms of the inspection limits; lack of recognizable scuff standard precluding evaluation of scuff machines; fair repeatability of exhaust analyzers; unacceptable performance

of all engine analyzer components (except RPM measurement devices); unacceptable performance of all hand tools (except dial (runout) gauges and micrometers); most improvement in Tennessee and Washington, D.C., least in Puerto Rico with respect to statistical parameter values of individual equipment types between first and third cycles; net improvement found in all projects from the beginning to the end of program. With respect to repair industry inspection equipment, the following are the findings: inadequate performance for implementing the established inspection criteria when judged on the basis of comparison with an engineering tolerance; performance of alignment analyzers not accurate enough to properly implement criteria identical to those in inspection demonstration projects; unsatisfactory performance of headlamp measurements in terms of inspection limits; and problems in all measurement areas of engine analyzer tests.

by Kenneth P. Joncas, et al  
Avco Corp., Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01037  
Rept. No. AVSD-0022-77-RR; 1977; 190p 3refs  
Rept. for Nov 1974-Dec 1976. See also HS-802 489, HS-802 490, HS-802 492, HS-802 493, HS-802 496, HS-802 497.  
Availability: NTIS

HS-802 492

# **DIAGNOSTIC MOTOR VEHICLE INSPECTION DEMONSTRATION PROJECTS, PROGRAM ENGINEERING SUPPORT. VOL. 3--APPENDIX B.**

The performance of the present research lane operation (as a part of the Motor Vehicle Diagnostic Inspection Demonstration Program operated under Title III of the Motor Vehicle Information and Cost Savings Act) at the S.W. Facility of the Department of Motor Vehicles in Washington, D.C. and four alternate designs (chassis dynamometer located at Hunter station, unloaded engine analysis test at lift station, surface-mounted chassis dynamometer at station 4, surface-mounted combination brake analyzer and chassis dynamometer at station 4), are analyzed. The alternate designs are modifications to the present operation and recognize construction and interface constraints imposed by the building layout and location and equipment-vehicle test procedures. The additional investment/modification costs and in-lane test restrictions imposed by each alternate design are also identified. For stations providing up to 10,000 inspections per year, the low-cost modification design (C - engine analyzer at lift station) can improve throughput potential with a cost saving of over \$5 per inspection. For stations providing between 10,000 and 20,000 inspections per year, considerable lane modification is required: more details are needed on modification and installation time and on cost as the surface mounted brake analyzer and the chassis dynamometer is installed at station 4; and alternatives should be considered, such as an above-ground lift at station 4. Policy should be established regarding brake inspection sequence. The effect of vehicle overheat and emissions test on lane design needs to be assessed. The appointment system should be used to increase the rate of utilization of the system.

by Kenneth P. Joncas, et al  
Avco Corp., Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01037  
Rept. No. AVSD-0022-77-RR; 1977; 56p  
Rept. for Nov 1974-Dec 1976. See also HS-802 489--HS-802 491, HS-802 493, HS-802 496, HS-802 497  
Availability: NTIS

HS-802 493

**DIAGNOSTIC MOTOR VEHICLE INSPECTION  
DEMONSTRATION PROJECTS, PROGRAM  
ENGINEERING SUPPORT. VOL. 4--APPENDIX C.  
SURVEY AND EVALUATION OF INSPECTOR  
TRAINING PROGRAMS**

A survey is made of training program sources for the diagnostic inspection personnel of the Motor Vehicle Diagnostic Inspection Demonstration Program operated under Title III of the Motor Vehicle Information and Cost Savings Act. Detailed descriptions of all identified currently operating training programs and all known pertinent information concerning a number of potential programs are presented. Training suggestions are given for the following five hypothetical situations: trainee has little or no mechanical experience but will be required to know all stations and to be capable of understanding causes behind displayed symptoms and of explaining them to the participant; trainee has little or no mechanical experience but will be required to operate all stations without, however, understanding causes behind manifested symptoms; trainee has broad mechanical experience, but has never worked with diagnostic equipment and will be required to know only certain stations; trainee has little or no experience and will work on safety inspection items only; and trainee has moderate mechanical experience, has worked with diagnostic equipment, will be placed in a supervisory capacity, and will be required to understand and explain sources of symptoms.

by Kenneth P. Joncas, et al  
Avco Corp., Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01037  
Rept. No. AVSD-0022-77-RR; 1977; 85p  
Rept. for Nov 1974-Dec 1976. See also HS-802 489--HS-802 492, HS-802 496, HS-802 497.  
Availability: NTIS

HS-802 496

**DIAGNOSTIC MOTOR VEHICLE INSPECTION  
DEMONSTRATION PROJECTS, PROGRAM  
ENGINEERING SUPPORT. VOL. 7--APPENDIX F.  
FUEL ECONOMY EVALUATION**

An evaluation is made of alternative methods of obtaining fuel economy data for the Motor Vehicle Diagnostic Inspection Demonstration Program operated under Title III of the Motor Vehicle Information and Cost Savings Act. Supplementary data to those provided by vehicle owners participating in the program were required. Dynamometer testing is technically acceptable and is cheaper than track testing. Facility performance in dynamometer testing varies widely, however. Short-cycle dynamometer fuel economy testing is difficult: fuel, tires, vehicle conditioning, and the dynamometer setup must be carefully controlled. Major uncertainties exist in knowing what incentives are needed to obtain desired vehicles and in the time required to test to desired accuracy. Available data are satisfactory to define the accuracy potential of state-of-the-art hardware magnitude of effects to be measured. The only way to justify a laboratory dynamometer program is to develop understanding of degradation phenomena. Such a program would include high accuracy fuel economy measurement, extensive parameter measurements of ignition, emissions, and compression, correlation of degradation with engine operating modes, and frequent testing. The best way to perform a group

experiment is by offering incentives to the participating vehicle owners to provide their own fuel economy records.

by Kenneth P. Joncas et al  
Avco Corp., Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01037  
Rept. No. AVSD-0022-77-RR; 1977; 155p 16refs  
Rept. for Nov 1974-Dec 1976. See also HS-802 489--HS-802 493, HS-802 497.  
Availability: NTIS

HS-802 497

**DIAGNOSTIC MOTOR VEHICLE INSPECTION  
DEMONSTRATION PROJECTS, PROGRAM  
ENGINEERING SUPPORT. VOL. 8--APPENDIX G.  
VEHICLE-IN-USE STANDARDS**

Appendix G (Vehicle-in-Use Standards) to a report on the work done by the program engineering support contractor in support of the National Highway Traffic Safety Administration (NHTSA). A methodology is presented by which vehicle in-use (VIU) standards can be evaluated in terms of their contribution to improved vehicle condition, the associated costs of motor vehicle inspection to achieve VIU condition, and the societal benefits of reduced accidents through improved VIU condition. It is in support of the Motor Vehicle Diagnostic Inspection Demonstration Program operated under Title III of the Motor Vehicle Information and Cost Savings Act. Both conceptual/analytical development and computer implementation are discussed. Three different models of periodic motor vehicle inspection (PMVI) express the probability that a motor vehicle is defective as a monotonically increasing function of time since inspection. Two hard failure models deal with inspection items that fail completely with no prior period of degraded performance such as headlights and taillights, external tire damage, and brake hydraulic failures. The third model deals with inspection items that exhibit continuously degrading performance prior to total failure, e.g. tire tread depth, brake lining thickness, brake performance, shock absorbers, and steering and suspension linkages. Evaluation of the effectiveness of the safety inspection is best done by use of safety, criticality factors, equations for which are derived. A cost methodology is derived, incorporating the elements of direct cost of inspection, the cost of time spent by the vehicle owners waiting for the actual inspection item to be accomplished, and the indirect cost of inspection (e.g. cost of owners' travel to and from the inspection site, fixed administrative costs of the inspection center). Techniques are given for parameter calculation, benefit calculation, and cost data reduction.

by Kenneth P. Joncas et al  
Avco Corp., Avco Systems Div., 201 Lowell St., Wilmington, Mass. 01887  
Contract DOT-HS-5-01037  
Rept. No. AVSD-0022-77-RR; 1977; 182p 30refs  
Rept. for Nov 1974-Dec 1976. See also HS-802 489--HS-802 493, HS-802 496.  
Availability: NTIS

respective major tasks during the first four months of the Research Safety Vehicle (RSV) program forms the body of the report. The following are the tasks: inflatable restraints, front seat passive belt restraints, structural refinement, systems refinement, plastic material improvements, electronic subsystem, braking and handling, durability tests, compatibility analysis, diesel engine, high technology engine/ transmission, structure fabrication, systems fabrication and installation, dynamic crash tests, environmental tests, benefit/cost analysis, large vehicle design, advanced engine for a large RSV, glazing, production planning, and tooling. Separate progress reports on work done for this project by subcontractors are appended.

Minicars, Inc., 35 LaPatera Lane, Goleta, Calif. 93017  
Contract DOT-HS-7-01552  
1977; 169p 5refs  
Availability: Reference copy only

HS-802 508

#### **FUTURE OF THE NATIONAL HIGHWAY SAFETY PROGRAM. FINAL REPORT**

The future of the National Highway Safety Program is discussed in terms of what transpired at the Conference on the Future of the National Highway Safety Program held 6-9 Mar 1977. In 1976, the National Highway Traffic Safety Administration (NHTSA) and the Federal Highway Administration (FHWA) requested that the Transportation Research Board (TRB) convene a conference to elicit reactions from the highway safety community on issues facing the national highway safety effort in the decade ahead. A steering committee of national highway safety leaders was established to plan and conduct the conference. This report is divided into the following sections: summary of recommendations of six workshops, conference plan, perspective (evolution of highway safety efforts), introduction to the Highway Safety Act of 1966, Federal role in highway safety, workshops: discussion and recommendations, text of the Highway Safety Act of 1966, discussion of the issues and alternatives (prepared by NHTSA and FHWA), and a list of participants. The six workshops focused on the following topics: highway safety standards and their use, Federal-state program management, state-local relationships, research and manpower development, private-sector involvement, and the use of financial incentives and sanctions. To summarize the workshop conclusions, it is felt that the present 18 highway safety standards be replaced by two types of requirements for state program approval (requirements dealing with features in which national uniformity is considered essential, and a second condition requiring approval of the procedures used by a state to plan and evaluate its program efforts), that state governors be responsible for the administration and performance of state highway safety programs, that, on the Federal level, the National Highway Safety Program be administered as a single program, that the Federal government continue to rely on the states to aid in the highway safety efforts of local jurisdictions and require that a minimum of 40% of a state's highway safety grant under the 1966 Act be expended by local jurisdictions,

tives.

National Acad. of Sciences, Transportation Res. Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418  
Contract DOT-HS-7-01557  
Rept. No. TRB-SP-178; 1977; 48p  
Rept. for Dec 1976-Jun 1977. Also available as HS-021 146, published by Transportation Res. Board (\$2.20).  
Availability: NTIS

HS-802 509

#### **ASSESSMENT OF SELECTED STATE AND COMMUNITY PROGRAMS. THE HIGHWAY SAFETY ACT OF 1966, SECTION 402**

Over the past six years the State and Community Grant Program, authorized under Section 402 of the Highway Safety Act of 1966, has channeled more than \$370 million to the fifty states, the District of Columbia, and Puerto Rico. The money is to stimulate, improve, and upgrade highway safety activities at the state and local levels. The Act requires that each state develop comprehensive highway safety plans based on broad standards (guidelines) issued by the Secretary of Transportation. The approach to the assessment of the State and Community Grant Program presented herein traces what has happened through the following steps: what was bought with Federal funds; how much of a money match was made by the States; how were the purchased items used--what did this yield; what did the states and localities do in response to the Federal input--support, follow-on, expansion, increased efficiency, and shift of emphasis; was the state action desirable, responsive, useful in some measurable way toward enhancing highway safety; what measures or indicators can be devised and used to reflect the output of the state-wide highway safety program. Five standard areas (driver education, alcohol in highway safety, traffic records, emergency medical services, police traffic services) representing 80% of the funds obligated to the state and Community Program were analyzed. Data covering FY 1968 through FY 1973 were obtained for the fifty states, the District of Columbia, and Puerto Rico. For these areas and these years, it was determined that items costing over \$315 million were bought. Over \$240 million of that amount were Federal Grant Program funds (Section 402), yielding a hard match ratio of 1.32. Stated another way this means that for every Federal grant dollar, the states put up 32 cents towards the actual cost of the purchase. In effect, therefore, Federal grant money paid for 76% of the actual cost. The five standard areas are treated separately.

National Hwy. Traffic Safety Administration, Planning and Programming, Washington, D.C. 20590  
1973; 99p  
Availability: Corporate author



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1975 PLYMOUTH FURY SEAT[ SIDE CRUSH OF SEAT  
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PLYMOUTH FURY SIDE, 2. 1975 FORD TORINO  
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CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
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TEST NO. 2, CAR-TO-CAR FRONT TO SIDE[ 60°  
ANGLE, DECEMBER 9, 1976; STATIC CRUSH TEST OF  
1975 PLYMOUTH FURY SEAT[ SIDE CRUSH OF SEAT  
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1975 FORD TORINO FRONT-TO-ANGLED 1975  
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FRONT-TO-ANGLED BARRIER, 3. SAE CONTOURED  
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RESIDUAL STRESS AND FATIGUE STRENGTH OF  
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DEVELOPMENT OF 40-150 KW STIRLING ENGINES  
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EQUIPMENT, TOTAL ENERGY SYSTEMS AND ROAD  
VEHICLES

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PREDICTING TARGET-DETECTION DISTANCE WITH  
HEADLIGHTS

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CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TEST: 1. TYPE OF  
TEST: CAR-TO-CAR, FRONT-TO-SIDE, 60° ANGLE

HS-802 431

CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TESTS: CRASH  
TEST NO. 2. CAR-TO-CAR FRONT TO SIDE 60°  
ANGLE, DECEMBER 9, 1976; STATIC CRUSH TEST OF  
1975 PLYMOUTH FURY SEAT SIDE CRUSH OF SEAT  
ONLY AS INSTALLED IN VEHICLE, DECEMBER 14,  
1976

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CAR-TO-SIDE IMPACT CRUSH AND CRASH TESTING  
(TASK 3) STATIC CRUSH TEST REPORT. TESTS: 1.  
1975 FORD TORINO FRONT-TO-ANGLED 1975  
PLYMOUTH FURY SIDE, 2. 1975 FORD TORINO  
FRONT-TO-ANGLED BARRIER, 3. SAE CONTOURED  
BARRIER-TO-ANGLED 1975 PLYMOUTH FURY SIDE

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COURSE GUIDE. NATIONAL TRAINING COURSE:  
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LOW MAINTENANCE MOMEX/TEFLON FABRIC  
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A TURBOCHARGED DIESEL ENGINE TEST FOR  
EVALUATING RING STICKING TENDENCIES OF  
HIGH QUALITY DIESEL ENGINE OILS

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## TEST

A TURBOCHARGED DIESEL ENGINE TEST FOR  
EVALUATING RING STICKING TENDENCIES OF  
HIGH QUALITY DIESEL ENGINE OILS

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AN ANALYSIS OF THE VARIABLES ASSOCIATED  
WITH THE ROLLER SHEAR FATIGUE TEST  
[FLEXIBLE URETHANE FOAMS]

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AUTOMOBILE CONSUMER INFORMATION FURY SIDE  
TEST PROGRAM, VOL. 1

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CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TEST: 1. TYPE OF  
TEST: CAR-TO-CAR, FRONT-TO-SIDE, 60° ANGLE

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CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TESTS: CRASH  
TEST NO. 2, CAR-TO-CAR FRONT TO SIDE[ 60°  
ANGLE, DECEMBER 9, 1976; STATIC CRUSH TEST OF  
1975 PLYMOUTH FURY SEAT] SIDE CRUSH OF SEAT  
ONLY AS INSTALLED IN VEHICLE, DECEMBER 14,  
1976

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CAR-TO-SIDE IMPACT CRUSH AND CRASH TESTING  
(TASK 3) STATIC CRUSH TEST REPORT. TESTS: 1.  
1975 FORD TORINO FRONT-TO-ANGLED 1975  
PLYMOUTH FURY SIDE, 2. 1975 FORD TORINO  
FRONT-TO-ANGLED BARRIER, 3. SAE CONTOURED  
BARRIER-TO-ANGLED 1975 PLYMOUTH FURY SIDE

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DESCRIPTION AND TEST RESULTS OF THIRD  
GENERATION CARTER STEAM SYSTEM AS IN-  
STALLED IN A VW DASHER.

HS-021 077

DESIGN AND TEST OF A 6000 PSI HYDRAULIC TUBE  
FITTING DEVELOPED TO MEET THE HIGH PRES-  
SURE TREND IN OFF-HIGHWAY EQUIPMENT

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EMISSION TEST CYCLES AROUND THE WORLD

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EVALUATION OF TEST DUMMY'S FLESH PARTS  
PRODUCED WITH SUBSTITUTE FOAMING COM-  
POUNDS. FIRST PROGRESS REPORT

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EVALUATION OF TEST DUMMY'S FLESH PARTS  
PRODUCED WITH SUBSTITUTE FOAMING COM-  
POUNDS. SECOND PROGRESS REPORT

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EVALUATION OF TEST DUMMY'S FLESH PARTS  
PRODUCED WITH SUBSTITUTE FOAMING COM-  
POUNDS. THIRD AND FOURTH PROGRESS REPORT,  
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## TESTING

CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TEST: 1. TYPE OF  
TEST: CAR-TO-CAR, FRONT-TO-SIDE, 60° ANGLE

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CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TESTS: CRASH  
TEST NO. 2, CAR-TO-CAR FRONT TO SIDE[ 60°  
ANGLE, DECEMBER 9, 1976; STATIC CRUSH TEST OF  
1975 PLYMOUTH FURY SEAT] SIDE CRUSH OF SEAT  
ONLY AS INSTALLED IN VEHICLE, DECEMBER 14,  
1976

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CAR-TO-SIDE IMPACT CRUSH AND CRASH TESTING  
(TASK 3) STATIC CRUSH TEST REPORT. TESTS: 1.  
1975 FORD TORINO FRONT-TO-ANGLED 1975  
PLYMOUTH FURY SIDE, 2. 1975 FORD TORINO

FRONT-TO-ANGLED BARRIER, 3. SAE CONTOURED  
BARRIER-TO-ANGLED 1975 PLYMOUTH FURY SIDE

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TESTING AND DESIGN APPLICATION PROCEDURES  
FOR HYDRAULIC HOSE ASSEMBLIES

HS-021 026

TESTING ROPS [ROLL-OVER PROTECTIVE STRUC-  
TURES] AND FOPS [FALLING OBJECT PROTECTIVE  
STRUCTURES] FOR SAFETY COMPLIANCE

HS-021 030

## TESTS

CAR-TO-CAR SIDE IMPACT CRUSH AND CRASH  
TESTING (TASK 3) TEST REPORT. TESTS: CRASH  
TEST NO. 2, CAR-TO-CAR FRONT TO SIDE[ 60°  
ANGLE, DECEMBER 9, 1976; STATIC CRUSH TEST OF  
1975 PLYMOUTH FURY SEAT] SIDE CRUSH OF SEAT  
ONLY AS INSTALLED IN VEHICLE, DECEMBER 14,  
1976

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CAR-TO-SIDE IMPACT CRUSH AND CRASH TESTING  
(TASK 3) STATIC CRUSH TEST REPORT. TESTS: 1.  
1975 FORD TORINO FRONT-TO-ANGLED 1975  
PLYMOUTH FURY SIDE, 2. 1975 FORD TORINO  
FRONT-TO-ANGLED BARRIER, 3. SAE CONTOURED  
BARRIER-TO-ANGLED 1975 PLYMOUTH FURY SIDE

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PSYCHOPHYSICAL TESTS FOR DWI [DRIVING  
WHILE INTOXICATED] ARREST. FINAL REPORT

HS-802 424

## THERMOMECHANICALLY

A FAMILY OF THERMOMECHANICALLY TREATED  
HIGH STRENGTH SHEET STEELS

HS-021 041

## THIRD

DESCRIPTION AND TEST RESULTS OF THIRD  
GENERATION CARTER STEAM SYSTEM AS IN-  
STALLED IN A VW DASHER.

HS-021 077

EVALUATION OF TEST DUMMY'S FLESH PARTS  
PRODUCED WITH SUBSTITUTE FOAMING COM-  
POUNDS. THIRD AND FOURTH PROGRESS REPORT,  
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1975 PLYMOUTH FURY SEAT] SIDE CRUSH OF SEAT ONLY AS INSTALLED IN VEHICLE, DECEMBER 14, 1976

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EPA-HDV-76-01	HS-020 985	SAE-760686	HS-021 028
FHWA-RD-77-26	HS-021 012	SAE-760689	HS-021 030
FHWA-RD-77-27	HS-021 102	SAE-760699	HS-021 031
FHWA-RD-77-28	HS-021 099	SAE-760692	HS-021 032

SAE-760699	HS-021 034	UDOT-MR-76-7	HS-021 012
SAE-760702	HS-021 035	UM-HSRI-75-8-2	HS-802 412
SAE-760707	HS-021 036	UM-HSRI-76-8-1	HS-802 411
SAE-760711	HS-021 037	UM-HSRI-77-14	HS-021 050
SAE-760713	HS-021 038	UM-HSRI-77-17	HS-021 009
SAE-760714	HS-021 039	UM-HSRI-77-31	HS-021 105
SAE-760715	HS-021 040	UMTA-MA-06-0049-77-5	HS-021 055
SAE-760716	HS-021 041	UMTA-OH-06-0018-77-1	HS-020 991
SAE-760717	HS-021 042	VHTRC-77-R61	HS-021 000
SAE-760718	HS-021 013	ZM-6015-V	HS-802 394
SAE-760719	HS-021 114	ZQ-5668-V-3	HS-802 395
SAE-760720	HS-021 115	1976-3E	HS-802 415
SAE-760721	HS-021 116	1976-4E	HS-020 993
SAE-760722	HS-021 117		HS-020 994
SAE-760723	HS-021 118		
SAE-760724	HS-021 119		
SAE-760725	HS-021 120		
SAE-770044	HS-021 121		
SAI-260-77-542	HS-021 084		
SCRI-TR77-2	HS-802 429		
TID-27218	HS-802 424		
TR-75-503	HS-021 085		
TRB-SP-178	HS-021 104		
	HS-802 508		

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